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The Indiana Enhanced I/M Program 0.5% On Road Testing 2009

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Glossary of Terms and Abbreviations

ADT	Average Daily Traffic
ASM	Acceleration Simulation Mode
Basic I/M	A set of vehicle I/M Program inspection requirements defined by the U.S. EPA that may be used in areas not required to implement an Enhanced I/M Program; the inspection procedure usually involves idle testing
BAR	California Bureau of Automotive Repair
BMV	Bureau of Motor Vehicles
CCM	Corner Cube Mirror
Clean Screening	The process of using RSD to identify vehicles with low emissions to exempt them from the required emission inspection at an inspection station
CO	Carbon monoxide
CO ₂	Carbon dioxide
Cutpoint	An emissions level used to classify vehicles as having met an emissions inspection requirement
Decile	A group containing one-tenth of the entries in a value ordered set
Enhanced I/M	A set of more rigorous vehicle I/M Program inspection requirements defined by the U.S. EPA usually involving IM240 testing
ESP	Environmental Systems Products
Evaporative Emitters	Vehicles releasing gaseous or liquid hydrocarbons from the fuel tank or fuel system
Excess Emissions	Vehicle emissions exceeding an I/M cutpoint
FTP	Federal Test Procedure
g/mi	Grams per mile, the units of measurement for FTP and IM240 tests
GVWR	Gross Vehicle Weight Rating
HC	Hydrocarbons
HDDV	Heavy-duty diesel vehicle
High-Emitter Identification	The on-road identification of vehicles with high emission levels
I/M	Inspection and Maintenance Program
IDEM	Indiana Department of Environmental Management

Idle Test	A tailpipe emission test conducted when the vehicle is idling and the transmission is not engaged
IM240 Test	A loaded-mode transient tailpipe emission test conducted when the vehicle is driven for up to 240 seconds on a dynamometer, following a specific speed trace simulating real world driving conditions
IM93 Test	A loaded-mode transient tailpipe emission test conducted when the vehicle is driven through a 93-second cycle on a dynamometer up to three times. The 93 seconds are the same as the first 93 seconds of the IM240 test.
IR	Infrared; electromagnetic radiation with a wavelength longer than that of visible light
KW/t	Kilowatts per metric ton, the units of measurement for vehicle specific power
LDDV	Light-duty diesel vehicle
LDGV	Light-duty gasoline-powered vehicle
LDGT	Light-duty gasoline-powered truck
NO	Nitric oxide also known as nitrogen monoxide
NO ₂	Nitrogen dioxide
NO _x	Oxides of nitrogen, usually measured as nitric oxide (NO)
OBDII	On Board Diagnostic system to detect emissions related problems required on all 1996 and newer light-duty vehicles
OREMS	On-Road Emissions Monitoring System, a protocol and associated performance standards for remote sensing vehicle emissions testing developed by the California BAR since 1995
Positive Power	An operating mode where the engine is generating power to drive the wheels
Repairable Emissions	The emission reductions obtained by repairing a vehicle. The amount of repairable emissions is equal to or greater than the amount of excess emissions
RSD	Remote Sensing Device
SDM	Source Detector Module, an RSD component that measures emissions
Tag Edit	The transcription of vehicle license plates or tags from images to text
TSI	Two-Speed Idle test
U.S. EPA	United States Environmental Protection Agency

UV	Ultraviolet; electromagnetic radiation with a wavelength shorter than that of visible light, but longer than X-rays
UV Smoke	An RSD measurement of particulate matter using UV light
VIN	Vehicle Identification Number
VMT	Vehicle Miles Traveled
VSP	Vehicle Specific Power; estimated engine power divided by the mass of the vehicle
VTR	Vehicle Test Record

1 SUMMARY

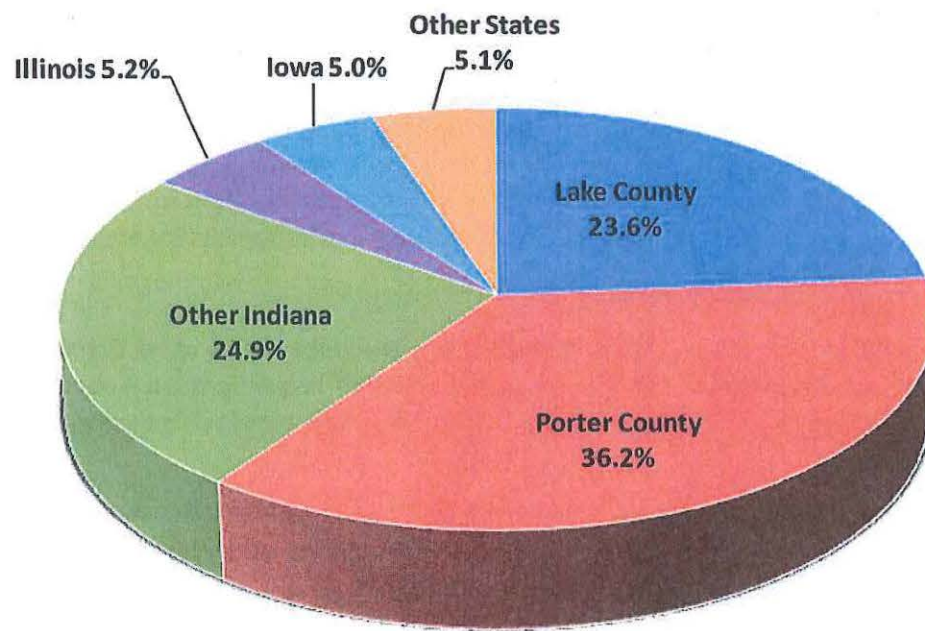
The Northern Indiana Inspection and Maintenance (I/M) Program contract between the Indiana Department of Environmental Management (IDEM) and Environmental Systems Products Inc. (ESP) requires on-road testing of 1% of the subject vehicles every two years. This report covers on-road testing performed in 2009 in the Northern Indiana I/M area comprising Lake and Porter counties. A remote sensing device (RSD) was used at roadside locations to measure emissions of passing vehicles and capture images of the vehicle plates. The vehicle plates were matched to registration records to obtain information about the type, age and weight class of the vehicle measured.

ESP collected 31,844 valid on-road vehicle emissions measurements from eight roadside locations from April through August 2009. License plates were decoded for 27,931 of the vehicles measured and 16,709 of these were matched to vehicle registrations in Lake and Porter County.

Survey Results

The chart below shows the registered jurisdiction of the vehicles measured in the nonattainment region. Of the 27,931 vehicles measured with readable plates, 59.8% were registered in the two counties, 24.9% were Indiana plates not identified as registered in Lake and Porter counties and 15.3% were from other states.

Figure 1-1: Registration Jurisdictions of Vehicles Measured in Lake and Porter Counties



On-road Vehicle Emissions

The average emissions of vehicles registered in the jurisdictions are shown in Table 1-1. Average emission rates of all vehicles measured on-road in the two counties, regardless of where they were registered, were 0.11 % carbon monoxide (CO) 16 ppm hydrocarbon (HC) hexane and 174 ppm oxides of nitrogen (NOx).

Vehicles identified as registered in Lake and Porter counties had lower emissions than other Indiana plates. Emissions of vehicles from other states were mostly within the range of those registered in Lake and Porter counties. The age and type of the vehicles traveling from other states is unknown.

Table 1-1 Fleet Emissions by Registered I/M Area

Jurisdiction	N	CO	HC	NOx	Smoke	VSP
Lake County	6,602	0.11	17	166	0.013	13.2
Porter County	10,107	0.09	10	145	0.014	14.7
Other Indiana Counties	6,951	0.16	25	228	0.021	14.1
Illinois	1,454	0.12	16	172	0.016	13.6
Iowa	1,395	0.10	13	172	0.013	14.0
Other States	1,420	0.11	15	161	0.016	14.3
Total	27,929	0.11	16	174	0.016	14.1

Figure 1-2 shows average emissions by age for passenger vehicles and light-duty trucks. Vertical lines with bars indicate 95% confidence intervals of the average values. RSD UV Smoke is a measurement of particulate emissions (PM). For diesel smoke, an RSD UV smoke value of one corresponds to one gram of particulate per 100 grams of combusted fuel. For gasoline vehicles the relationship between the RSD UV smoke value and particulate mass is less well defined and depends on the type of smoke, e.g. black carbon smoke, blue oil smoke or white coolant smoke, and is the subject of ongoing research.

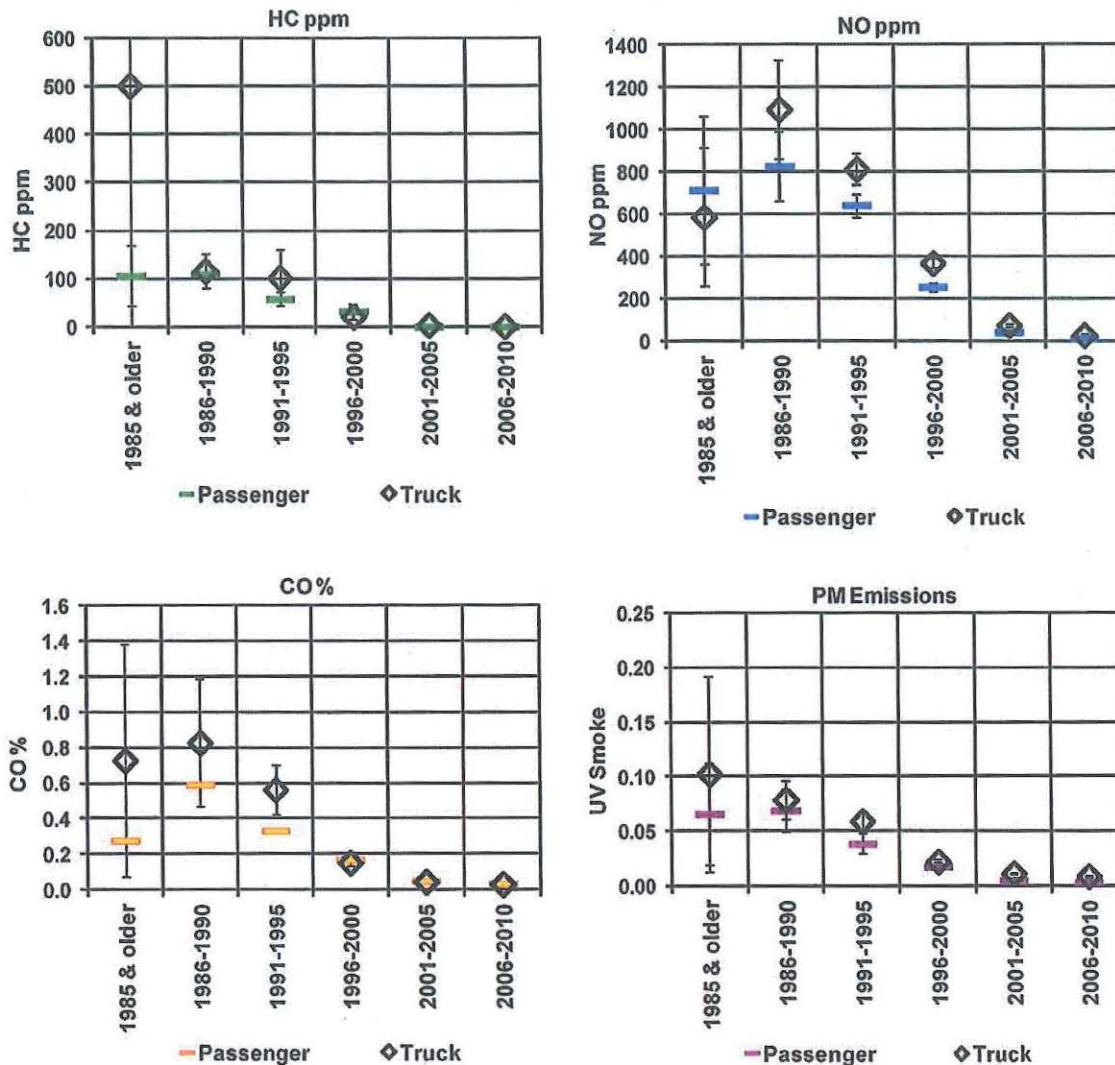
Emissions of 1996 and newer models are much lower than those of older models. The vast majority of 2001 and newer models had very low emissions. Older model trucks had higher average emissions than passenger vehicles of all pollutants. Light-duty trucks also have lower fuel economy and greater exhaust volume resulting in a larger mass of emissions.

Compliance with the I/M Program

Inspection records from January 2007 through December 2009 were examined to determine the last inspection for the vehicles measured on-road. Inspections were confirmed for 95.5% of 1981-2005 passenger models and 94.5% of trucks with a gross vehicle weight rating (GVWR) of up to 6000 lbs.

Confirmed inspection rates were higher for odd model year vehicles than for even model year vehicles. It is possible that more even model-year vehicles were inspected than were confirmed and that the overall compliance rate is higher than 95%.

Figure 1-2: Emissions by Vehicle Type and Model Year



High-Emitters

Gasoline powered vehicles had a highly skewed emissions distribution with a small percentage of high-emitters contributing a substantial portion of total light-duty vehicle emissions.

ESP identified high emitters using criteria used in similar on-road surveys conducted in Maryland. The criteria required at least two measurements to confirm a vehicle as being a high emitter. Sixty vehicles, 2.3% of vehicles with two or more measurements, exceeded the cutpoints on both of their last two measurements for the same pollutant. The sixty vehicles had average emissions that were 22 times higher for HC and 9 times higher for CO and NO_x than the average emissions of all vehicles with two measurements.

Forty-five percent of high emitters were 1995 and older models and 42% were 1996-1999 models.

Recommendations

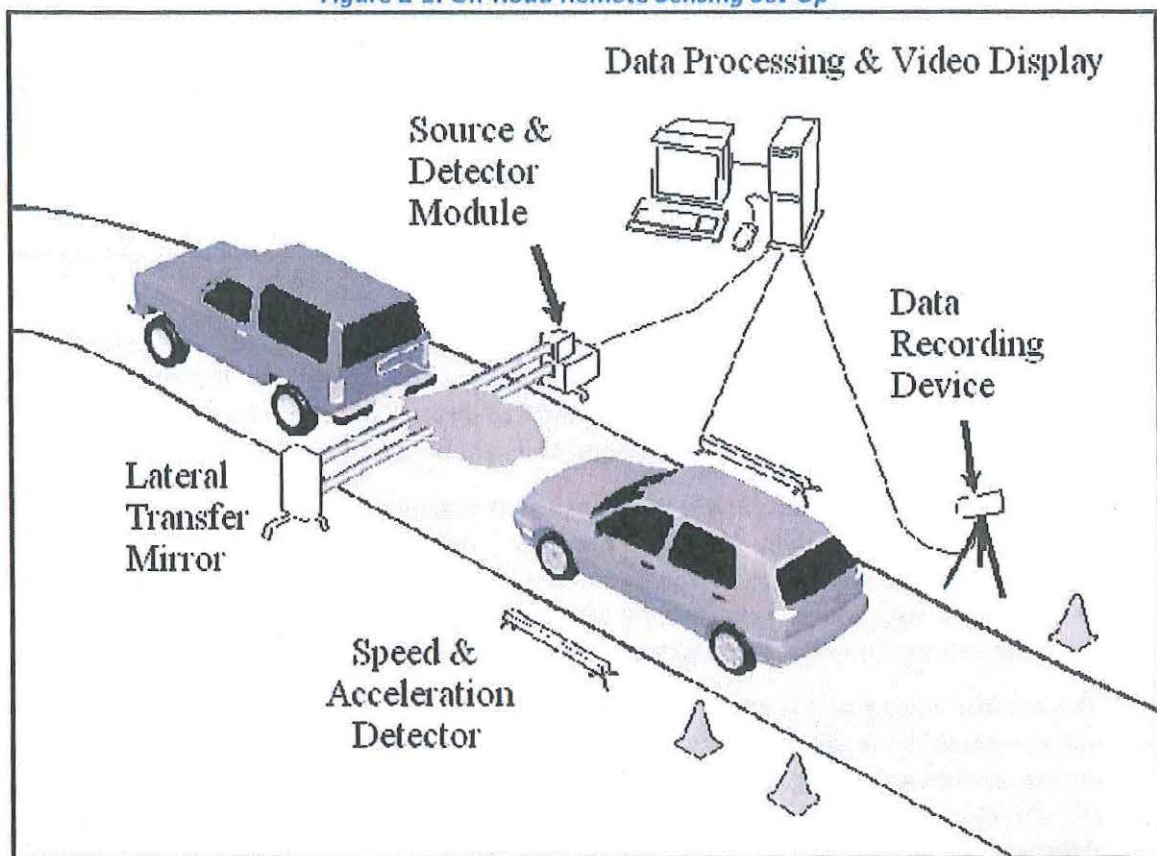
- A comprehensive on-road emissions measurement program could be a valuable supplement to the current I/M Program by:
 - Identifying on-road evaporative emitters, some of which will not be identified by OBD-II;
 - Identifying high-emitters not captured by the I/M Program, or failing between tests;
 - Monitoring on-road vehicles for compliance;
 - Providing feedback on the effectiveness of the Program and repairs;
 - Examining the impact of OBD-II readiness exemptions and other I/M Program design decisions and options, e.g. the inclusion or exclusion of additional models.
- Consider dual testing (IM93 and OBD-II) for 1996 to 1999 model year vehicles given the numbers of high-emitters for these models. California currently dual tests OBD-II models and will continue to dual test 1996-1999 models after legislation¹ to allow OBD-II only testing of 2000 and newer models becomes effective in 2013. The legislation also allows for dual-testing of 2000 and newer models with emission problems that may not be adequately detected by the vehicle's OBD-II system.
- Consider raising the GVWR limit on vehicles tested from 9000lbs to 10,000lbs or 14,000lbs. These heavier trucks have higher mass emissions and delivery trucks and shuttles have high vehicle miles traveled (VMT).
- Consider emissions testing for light-duty diesel powered vehicles. Light-duty diesel vehicles, although fewer in number, have particulate and NOx emissions that are many times higher than gasoline vehicle emissions.
- Consider implementing a clean screen pilot to reduce the I/M burden on owners of well maintained vehicles and develop a wealth of on-road measurements that provide better focus on high emitters.

2 EQUIPMENT AND SITES

2.1 Equipment Description

The remote sensing device (RSD) survey used the ESP's RSD4000 testing system. The RSD4000 detects vehicle emissions when a vehicle drives through an invisible light beam the system projects across a roadway. Figure 2-1 illustrates the remote sensing equipment set-up. The process of measuring emissions remotely begins when the RSD4000 Source & Detector Module (SDM) sends an infrared (IR) and ultraviolet (UV) light beam across a single lane of road to a Corner Cube Mirror (CCM). The mirror reflects the beam back across the street (creating a dual beam path) into a series of detectors in the SDM.

Figure 2-1: On-Road Remote Sensing Set-Up



Fuel specific concentrations of HC, CO, CO₂, NO and smoke are measured in vehicle exhaust plumes based on their absorption of IR/UV light in the dual beam path. During this process, the data-recording device captures an image of the rear of the vehicle, while the Speed & Acceleration Detector measures the speed of each vehicle.

The RSD units are housed in fully outfitted cargo-style vans. These vans are equipped with heating/cooling, a generator, and adequate storage for all components. The vans carry a full complement of road safety equipment and tools for making small repairs. The vans are equipped with additional lighting for testing during pre-dawn and post-dusk hours. The RSD4000 includes the following features:

- 1) A long beam range for safer, more versatile deployment;
- 2) Simple and easy setup with laser alignment aids;
- 3) Continuous automatic background compensation minimizes the need for field calibration. (Only one or two calibrations are generally required during a full day of data collection.);
- 4) Fourth generation real-time measurement validation;
- 5) Signal sensitivity and accuracy that significantly exceed 2002 California BAR certification standards;
- 6) Limited degrees of freedom in alignment resulting in improved optical stability and low noise for increased productivity, yielding more valid records;
- 7) A Windows operating system for ease of operation and multi-tasking;
- 8) A fuel specific smoke measurement using a UV wavelength that senses the fine particles invisible to traditional visible light opacity meters, and
- 9) Rugged assemblies requiring low maintenance.

2.2 Equipment QA/QC Audits

2.2.1 Factory Testing and Certification

When an RSD system is built at the Tucson Technology Center, it undergoes several steps to ensure accuracy. First, the source detector module is bench calibrated. It is then audited using several blends of gas. When the system is fully calibrated and assembled, it is tested again in the parking lot using an audit truck. The unit tests are based on the BAR OREMS specification.

An audit truck is a modified vehicle that uses a long exhaust stack to redirect the vehicle engine exhaust upwards and away from the roadway. Audit gases of known concentrations are dispensed through a simulated tailpipe routed to the rear of the audit truck. When the truck is driven past a roadside remote sensing SDM/CCM set of modules, the system measures the pollutant concentrations in the dispensed test gas instead of the vehicle engine exhaust.

The remote sensing unit is setup in a parking lot to avoid interference from other traffic. The auditor drives the audit truck through the remote sensing system 40 times for each gas blend during acceptance testing. ESP detector accuracy, including speed and acceleration, will meet the detector accuracy tolerances shown below for at least 97.5% (39/40) runs for each gas. Six different audit gas blends are used to verify the unit accuracy over a range of pollutant concentrations.

2.2.2 Detector Accuracy

The carbon monoxide (CO%) reading will be within $\pm 10\%$ of the Certified Gas Sample, or an absolute value of $\pm 0.25\%$ CO (whichever is greater), for a gas range less than or equal to 3.00% CO. Negative values shall be included and will not be rounded to zero. The CO% reading will be within $\pm 15\%$ of the Certified Gas Sample for a gas range greater than 3.00% CO. Negative values will be included and will not be rounded to zero.

The hydrocarbon reading (recorded in ppm propane) will be within $\pm 15\%$ of the Certified Gas Sample, or an absolute value of ± 250 ppm HC, (whichever is greater). Negative values will be included and will not be rounded to zero.

The nitric oxide (NO) reading (ppm) will be within $\pm 15\%$ of the Certified Gas Sample, or an absolute value of ± 250 ppm NO, (whichever is greater). Negative values shall be included and will not be rounded to zero.

2.2.3 Speed and Acceleration Accuracy

The vehicle speed measurement will be accurately recorded within ± 1.0 mile per hour.

The vehicle acceleration measurement will be accurately recorded within ± 0.5 mile per hour / second.

2.2.4 Daily Set-Up and Calibration

Every scheduled work day, the operator drives to an existing or new test site. The operator's first duty is to provide a safe work area for themselves and passing motorists. The next step is to set up the source detector module and allow the electronic components within to warm up for a minimum of 30 minutes. Following the set up and alignment of the other components, the SDM is aligned and ready for calibration.

An automated calibration utilizing a mechanized gas cell within the SDM is a method of testing the equipment without the need to drive an audit truck past the unit. During a gap in the passing traffic, a test gas within a sealed cell, with a known blend of HC, CO, CO₂ and NO, is maneuvered into the optical path of the remote sensing beam. If necessary, the instrument set-up is adjusted so that the pollutant values measured by the unit, match the known concentrations of pollutants in the test gas blend.

Calibration for the RSD4000 occurs once at the beginning of the day and at mid-day if conditions warrant.

2.2.5 Equipment Audits

After each daily calibration, the operator is required to perform an audit to verify an optimal calibration. A puff audit is a method of testing the equipment without the need to drive an audit truck past the unit. During a gap in the passing traffic, a test gas with a known blend of HC, CO CO₂ and NO, is puffed into the optical path of the remote sensing beam. If the audit passes a predetermined pass/fail tolerance, the operator is allowed to begin testing vehicles. If not, the operator is required to realign and recalibrate the system until it passes the audit process.

Audits for the RSD4000 occur every hour (2 hour maximum before system lockout occurs), twice when a calibration is performed (once before to earmark data and once after to begin testing) and once at the end of the test collection period to earmark the data.

2.2.6 Audits (drive-by audits)

Every month during the course of data collection, an audit truck was utilized to audit the RSD4000 systems.

The audit truck is outfitted with a gas cylinder rack that holds 4 compressed gas cylinders. Each gas cylinder is equipped with a high flow regulator, a high flow solenoid and a Tygon hose, which is adapted to a simulated tailpipe. Inside the truck cab, the audit truck operator has the ability to switch power from solenoid to solenoid to select the appropriate audit gas cylinder for drive-by audits. A traffic cone is placed 60-70 feet preceding the test site. This is used as a mark to begin the flow of gas to ensure there is an adequate plume of audit gas as the truck passes the RSD4000. The typical gas blends used in the audits are shown below:

	HC (ppm)	CO	CO ₂	NO (ppm)
Blend # 1	500	0.5%	14.70%	3000
Blend # 2	3000	1.00%	14.38%	2000
Blend #3	2000	2.75%	13.10%	500
Blend #4	6000	5.00%	11.55%	250

In addition to the equipment, the operator is also audited for following procedures: site setup, calibration, camera alignment, traffic safety and documentation.

2.3 Overview of 0.5% Sample

2.3.1 Sample Design Criteria

The objective is to obtain the 0.5% sample from sites that will be generally representative of vehicles operating in the I/M program areas.

As shown in Figure 2-2: Site Locations, eight sites were used to collect RSD data. The intent was to collect tests on a random sample that is representative of all the on-road vehicle traffic. Measurements are distributed geographically with no one area receiving an undue amount of testing.

2.3.2 Description of Sample Site Characteristics

Site selection is critical to obtaining RSD measurements that are representative of vehicle operation. Recommended site attributes include:

- Absence of cold start vehicle operating conditions;
- Sites where vehicles will generally be accelerating or driving at a steady speed uphill to avoid the highly variable tailpipe emissions that can occur under deceleration;
- Absence of enrichment due to high load conditions;
- Single lane operation;
- High volume traffic;
- Unobtrusive citing of the remote sensing equipment;
- Stability in the traffic mix from one year to the next; and
- Adequate median space for safe operation of the RSD equipment

2.4 Sites selected for studies

Table 2-1 lists the site locations selected for the 0.5% sample. All the sites selected are on-ramps or exit loops that provide the required physical characteristics of an appropriate RSD site. Sites were pre-qualified for:

- Single lane operation with space for the RSD equipment to be deployed without disrupting traffic flow
- Geographically dispersed throughout the I/M area;

- A satisfactory percentage of valid readings; and
- An adequate traffic volume.

2.4.1 Sites Used

Table 2-1 shows the survey sites used and the number of days of on-road data collection.

Figure 2-2 displays the distribution of the sites.

Detailed descriptions of the sites with pictures and layouts are in Appendix A

Table 2-1: Sites Used

Site Code	Location	City	County	Degrees of Grade	Valid RSD in Desired VSP Range
IN03	61st Ave West to I-65 North	Merrillville	Lake	0.37	644
IN05	IN 2 to IN 49 South	Valparaiso	Porter	0.57	7,396
IN16	US 30 to IN 49 North	Valparaiso	Porter	0.20	5,922
IN2-49N	IN 2 to IN 49 North	Valparaiso	Porter	1.20	6,985
IN30	US 231 to I-65 North	Crown Point	Lake	1.20	6,326
IN6165	E 61st Ave East to I-65 North	Hobart	Lake	0.20	363
INBURR	Burr St to I-80 / I-94 East	Gary	Lake	0.23	3,951
S61ST	E 61st Ave East to I-65 South	Merrillville	Lake	0.60	257
					31,844

Figure 2-2: Site Locations



2.5 Data Screening

The RSD system applies checks to determine the validity of emissions measurements. These include determining if a sufficient exhaust plume was measured. The general criteria for an RSD system 'valid' measurement include:

- The system was active and calibrated;
- A valid exhaust gas measurement was recorded;
- A valid speed and acceleration was recorded; and
- A readable plate was recorded and transcribed.

Particular applications can require further screening. ESP applied the following additional screening checks to the RSD measurements to ensure the data used were representative of the vehicle emissions:

- Screening for Vehicle Specific Power (VSP) range; and
- Screening of hourly observations to check for cold starts.

The exhaust plume validations and the additional screening procedures are described in the following paragraphs.

2.5.1 Valid Exhaust Plumes

The RSD4000 unit takes many measurements of each exhaust plume in the one half second after each vehicle passes the equipment.

The basic gas record validity criteria applied are:

- A gas record is valid if there are at least 5 plume measurements where the sum of the amount of CO₂ and CO gas exceed 10%-cm¹; or
- A gas record is valid if there are at least 5 plume measurements where the sum of the amount of CO₂ and CO gas exceed 5%-cm and the background gas values are very stable (not changing faster than a specified rate) at the time the front of the vehicle breaks the measurement beam.

2.5.2 Vehicle Specific Power (VSP)

VSP provides an estimate of the relative power output of the vehicle based upon speed, acceleration and slope at the site and for light-duty vehicles is defined by the following equation:

$$\text{VSP} = 4.364 * \sin(\text{Grade in Deg}/57.3) * \text{Speed} + 0.22 * \text{Speed} * \text{Accel} + 0.0657 * \text{Speed} + 0.000027 * \text{Speed} * \text{Speed} * \text{Speed}$$

¹ The unit of measurement 10%-cm is a measurement of the amount of a gas in the optical path. In this case, if all the molecules of the gas in the path were collected together into just one centimeter of the path then the concentration of the gas in the one-centimeter would be 10%.

Engine load is a function of the vehicle speed and acceleration, the slope of the site, vehicle mass, aerodynamic drag, rolling resistance, and transmission losses. The effects of these forces can be aggregated into a single parameter called VSP, which was the topic of a presentation at the Ninth Coordinating Research Council (CRC) On-road Vehicle Emissions Workshop². The CRC E-23 Project³⁴ further developed the concept of vehicle specific power. In 2002, EPA adopted the use of VSP as a parameter for predicting vehicle emissions in the recently adopted Motor Vehicle Emissions Simulator (MOVES) emissions inventory model that replaces Mobile⁵.

Studies have found vehicle emissions to be more stable and more representative of the average in-use emissions of a vehicle when the engine is under a light to moderate load such as occurs when cruising above 30 mph, during non-aggressive acceleration, or driving up inclines. In day-to-day use, a majority of fuel is consumed in light to moderate engine load. Therefore ESP requires that vehicle emission observations be made when VSP is positive and sites are selected to measure vehicles when they are typically operating with moderate engine load. For CO high-emitter identification, upper limits are placed on VSP depending on the model year.

2.5.3 Screening of Hourly Observations

ESP is concerned about vehicles operating in cold start mode or under conditions when exhaust plumes condense to steam. Vehicles measured under these conditions could appear to have high HC emissions without any emission system problems. To investigate this possibility, ESP tabulated for each site and hour the percentage of vehicles up to 5 years old that exceeded 150 ppm HC (Table 2.3). The percent of vehicles up to 5 years old that exceed 150 ppm HC tend to be higher during periods of near freezing temperatures. All hours with twenty or more measurements had less than 5% of new models with emissions greater than 150 ppm HC. Table 2-4 shows that temperatures were never close to freezing. Temperatures also never exceeded 100°F, which can lead to high evaporative emissions.

Table 2-3: Percentage of New Model Measurements Exceeding 150 ppm HC

Day	Unit	Site	06:00 & earlier	7:00	8:00	9:00	10:00	11:00	12:00	13:00	14:00	15:00	16:00
17-Apr-09	06064605	IN03											
18-Apr-09	06064605	IN03							0%				
23-Apr-09	06064605	INBURR											
24-Apr-09	06064605	INBURR							0%				
4-May-09	06064605	INBURR							0%				
5-May-09	06064605	INBURR			0%							0%	
6-May-09	06064605	INBURR											
7-May-09	06064605	INBURR										0%	
8-May-09	06064605	INBURR				0%			0%	0%	0%	0%	
11-May-09	06064605	IN03											
14-May-09	06064605	S61ST											
19-May-09	06064605	INBURR											
20-May-09	06064605	IN6165											
12-Jun-09	06064605	IN30					0%	0%	0%		0%	0%	
15-Jun-09	06064605	IN30		0%	1%	0%	0%	0%	0%	0%	2%	0%	
16-Jun-09	06064605	IN30		0%	0%		0%	0%	0%	0%			
23-Jun-09	06064605	IN30	0%	0%	1%	0%	0%	0%	0%	0%	0%	0%	
24-Jun-09	06064605	IN16		0%	0%	0%	0%	0%	0%	0%	0%	0%	
25-Jun-09	06064605	IN16		0%	0%	0%	0%	0%	0%	0%	0%	0%	
26-Jun-09	06064605	IN16		0%	0%	0%	0%	0%	0%	0%	0%	0%	
29-Jun-09	06064605	IN16		0%	0%	0%	0%	0%	0%	0%	0%		
30-Jun-09	06064605	IN2-49N			0%	0%	0%	0%	0%	0%	0%	0%	
2-Jul-09	06064605	IN2-49N		0%	0%	0%	0%	0%	0%	0%	0%		
9-Jul-09	06064605	IN2-49N			0%	0%	0%	0%	0%	0%	0%		
13-Jul-09	06064605	IN05		0%		0%	0%	0%	0%	0%	0%		
14-Jul-09	06064605	IN05		0%	0%	0%	0%	0%	0%	0%	0%		
15-Jul-09	06064605	IN05						0%	0%	0%			
16-Jul-09	06064605	IN05							0%	0%			
17-Jul-09	06064605	IN05							0%	0%			
21-Jul-09	06064605	IN05			0%	0%	0%		0%	0%	0%		
24-Jul-09	06064605	IN05			0%	0%		0%	0%	0%			
27-Jul-09	06064605	IN05			0%				0%	0%			
3-Aug-09	06064605	IN2-49N					0%	0%	0%	0%			
4-Aug-09	06064605	IN2-49N		3%		0%	0%	0%	0%	0%			
5-Aug-09	06064605	IN2-49N		0%	0%	0%	0%						
6-Aug-09	06064605	IN2-49N					0%	0%	0%	0%	0%	0%	0%

Table 2-4: Average Hourly Temperature Fahrenheit

Day	Unit	Site	06:00 & earlier	7:00	8:00	9:00	10:00	11:00	12:00	13:00	14:00	15:00	16:00
17-Apr-09	06064605	IN03							68				
18-Apr-09	06064605	IN03						71	75	78			
23-Apr-09	06064605	INBURR						64	67	70			
24-Apr-09	06064605	INBURR						81	84	88			
4-May-09	06064605	INBURR					70	72	76	77			
5-May-09	06064605	INBURR		61	64	68	71	75	78	76	72	70	70
6-May-09	06064605	INBURR		60	61								
7-May-09	06064605	INBURR			67	68	72	76	79	80	82	83	82
8-May-09	06064605	INBURR			66	67	69	69	73	76	78	79	81
11-May-09	06064605	IN03					60	65	69	70	74	74	77
14-May-09	06064605	S61ST						77	77	76	74	74	
19-May-09	06064605	INBURR						77	78	82	84		
20-May-09	06064605	IN6165						83	84	89	91	91	
12-Jun-09	06064605	IN30					85	83	88	89	86	82	
15-Jun-09	06064605	IN30		74	80	83	87	88	87	89	87	86	
16-Jun-09	06064605	IN30		68	69		76	75	75	75			
23-Jun-09	06064605	IN30	78	82	88	93	98	103	103	99	100	97	
24-Jun-09	06064605	IN16		78	82	88	91	95	98	94	86	86	
25-Jun-09	06064605	IN16		78	81	84	89	91	93	97	100	100	
26-Jun-09	06064605	IN16	77	77	79	81	84	86	89	90	90	90	
29-Jun-09	06064605	IN16	66	68	71	74	76	78	80	80	78	79	
30-Jun-09	06064605	IN2-49N	65	64	66	68	68	74	74	69	67	69	
2-Jul-09	06064605	IN2-49N		64	65	68	70	74	77	79	81		
9-Jul-09	06064605	IN2-49N		69	72	75	79	84	89	91	94		
13-Jul-09	06064605	IN05	69	75	83	86	90	90	89	86	83		
14-Jul-09	06064605	IN05		71	77	80	77	82	85	85	83		
15-Jul-09	06064605	IN05						81	81	85			
16-Jul-09	06064605	IN05						87	89	89			
17-Jul-09	06064605	IN05						75	77	74			
21-Jul-09	06064605	IN05	76	76	84	86	86	88	87	85	84	82	
24-Jul-09	06064605	IN05	74	82	88	89		94	90	89			
27-Jul-09	06064605	IN05	77	86	88	92		93	92	89	89		
3-Aug-09	06064605	IN2-49N				74	77	77	79	84			
4-Aug-09	06064605	IN2-49N		74	77	82	84	84	84	85			
5-Aug-09	06064605	IN2-49N	65	68	72	76	79						
6-Aug-09	06064605	IN2-49N				73	76	79	82	84	88	89	91

2.5.4 Screening of Day-to-Day Variations in Emission Values

Each day's emission measurements of 2005 and newer model year vehicles were ordered by value and divided into ten groups or deciles each containing an equal number of the ordered measurements. Day-to-day decile emission values were compared for 2005 and newer vehicles. Only a small percentage of these newer vehicles are expected to have high emissions. We expect, therefore, their intermediate decile emission values should not vary significantly from day-to-day, from site-to-site or between RSD units. In Figure 2-3, the daily HC decile values of measurements are plotted side-by-side. The right hand legend indicates the color of each decile number. This comparison revealed median values for 2005 and newer model year vehicles that ranged day-to-day from -14.4 ppm to -0.2 ppm. Although these variations are well within the HC specification of the RSD units they are significant compared to average fleet emissions for newer vehicles.

Day-to-day decile CO, NO and UV smoke values for 2005 and newer model year vehicles are shown in Figures 2-5 to 2-7. Median values for CO, NOx and smoke were +0.009% to +0.019%, -2 to +20 ppm and -.002 to +0.01 respectively. These negative and positive values are very small and adjustments were not applied to these pollutants.

RSD HC Deciles - 2005 & Newer Vehicles VSP: 3-22
(Before Adjustment)

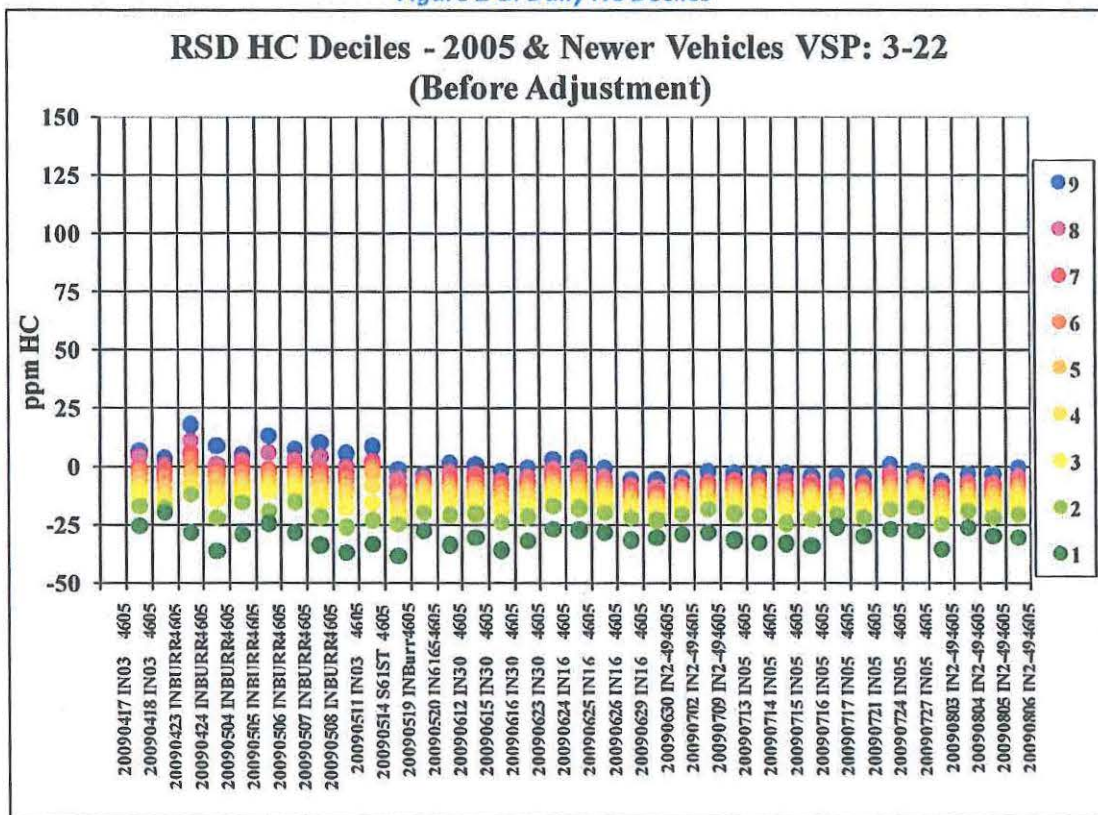


Figure 2-4: Daily HC Deciles – After Adjustment

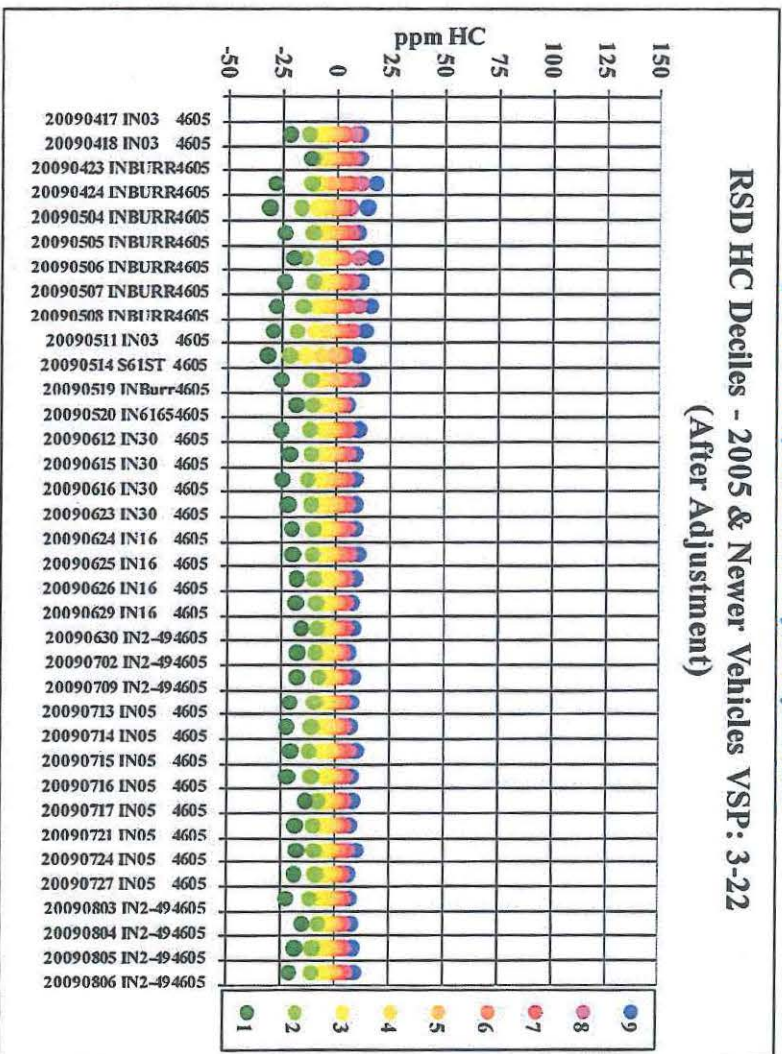


Figure 2-5: Daily CO Deciles

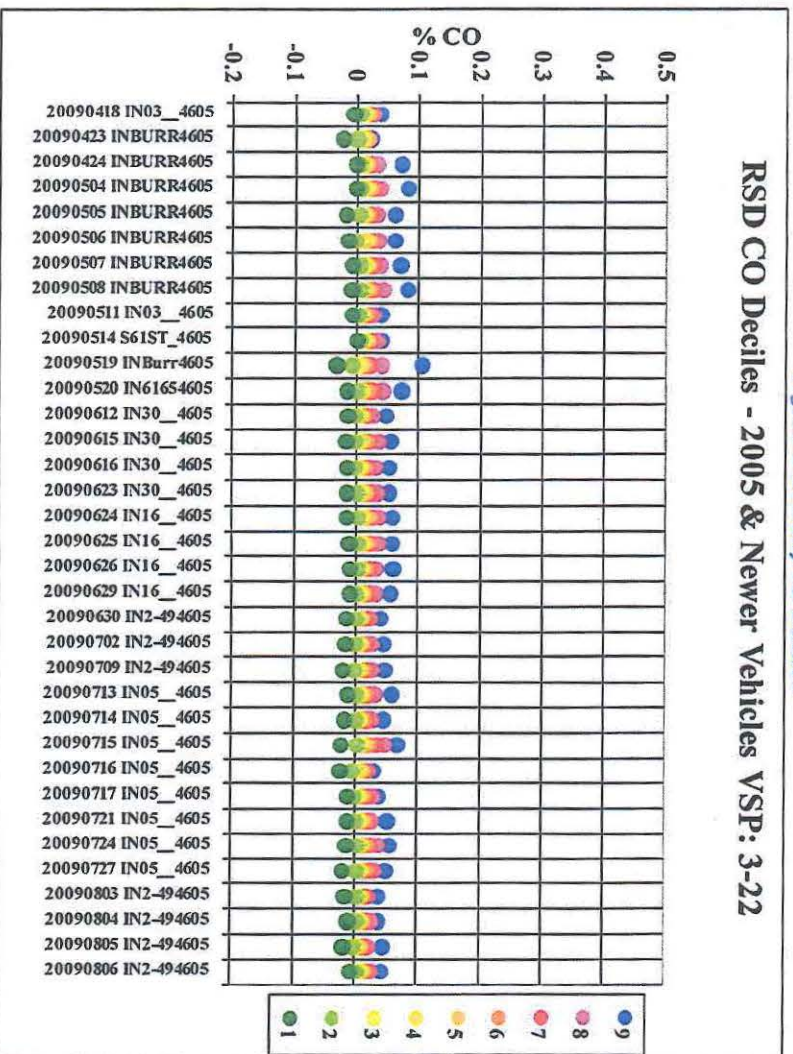


Figure 2-6: Daily NO Deciles

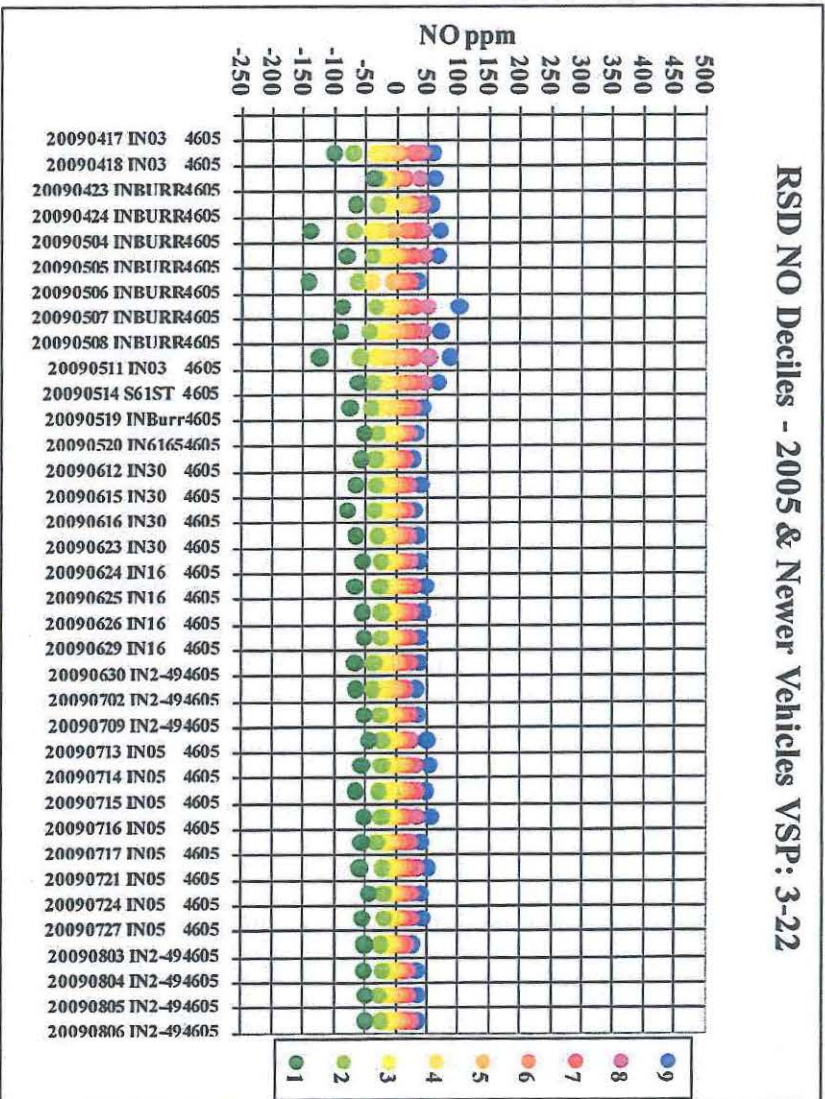
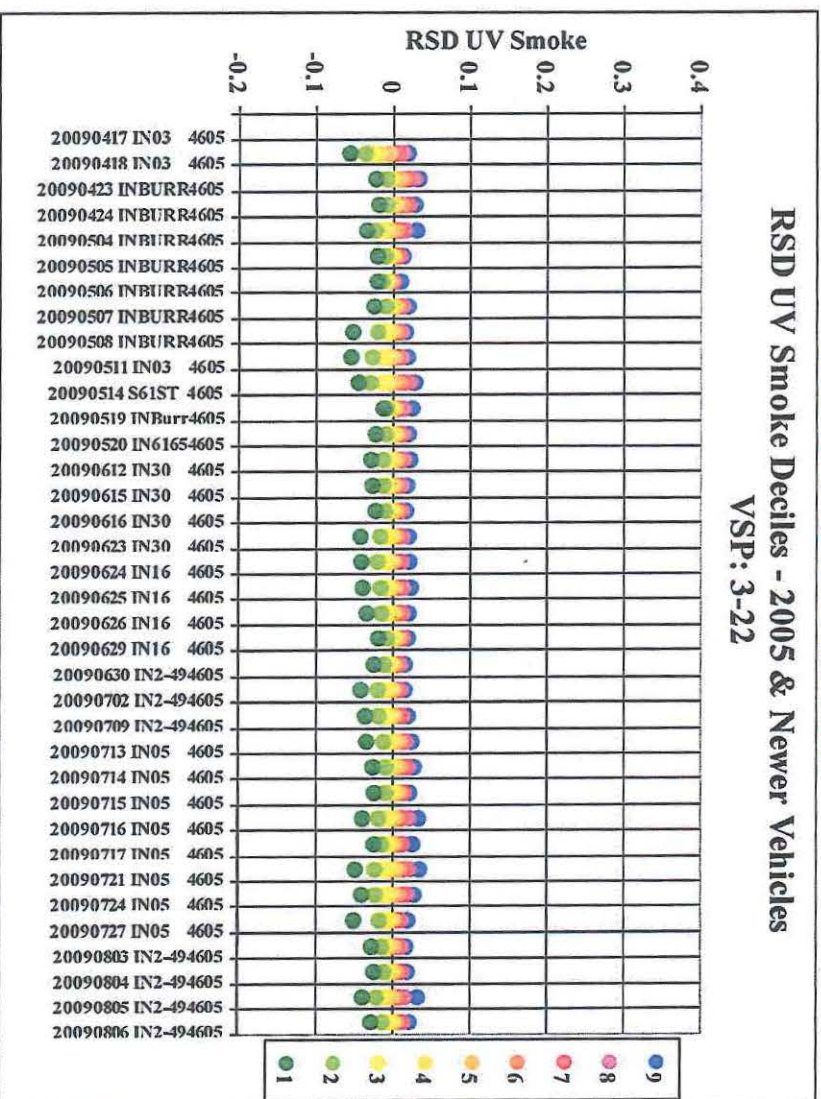


Figure 2-7: Daily UV Smoke Deciles



2.6 Sources of Data and Description of Elements

Data used in the analyses in this report come from two primary sources, the RSD on-road measurements and the Bureau of Motor Vehicles (BMV) registrations database.

In the following description of data elements, key fields that are used to access other tables are shown in **bold**.

2.6.1 RSD Measurements

For each vehicle the following information is collected:

- **Vehicle Plate or tag;**
- Date and Time;
- **Site Reference;**
- HC, CO, CO₂, NO and UV Smoke emissions; and
- Speed and acceleration.

2.6.2 RSD Sites

For each site the following information is collected:

- **Site Reference;**
- Description of location; and
- Slope of site in degrees;

2.6.3 Vehicle Registration Data

Data from the RSD is matched to the vehicle registrations data provided by BMV. Using the vehicle plate identified by RSD, the registration file is accessed to determine the vehicle identification number (VIN) and additional information about the vehicle such as model year and county in which it is registered. In order to obtain an accurate match, the plate number, a two-letter plate type and the registration year are required. BMV uses a series of plate types and the same plate number can be issued to more than one plate type. For this survey, plates were used only if they were not used for more than one plate type. This eliminated about 10% of potential matches. In addition, 2009 registration data were available only for Lake and Porter counties. Some data were obtained for vehicle plates registered to other counties but only on a limited subset of the plates observed.

Another limitation is that vehicle plates do not always remain with the same vehicle. Upon purchase of a new or used vehicle, an owner may transfer the same plate from the old vehicle to the new vehicle. In this situation, data processing delays can result in incorrect identification of some vehicles measured by RSD unless BMV transaction dates are included in the data, which was not the case for this survey.

2.6.4 NO vs. NO_x

The vast majority of nitric oxides emitted from the vehicle tailpipe are in the form of NO. The NO is later oxidized to NO₂ and other oxides of nitrogen, which are collectively referred to as NO_x. The RSD unit measures NO and typically we report NO values.

To convert from NO to NO_x, a factor of 1.03 is applied. In Section 5, where individual vehicles are compared to standards for determination of high emitters, the NO values are converted to NO_x and adjusted for humidity as described below. Charts and tables in Section 5 report NO_x values.

2.6.5 NO_x and Humidity

Higher humidity reduces vehicle NO_x emissions. When vehicles are inspected in the I/M program, humidity correction factors are applied to adjust NO_x measurements to values that would have been achieved when the water vapor content is 75 grains per lb. For temperatures above 75 degrees Fahrenheit (°F):

$$\text{Correction factor} = e^{(.004977*(H-75) - .004447*(T-75))}$$

For temperatures below 75 °F:

$$\text{Correction factor} = 1/(1.0 - .0047*(H - 75.0))$$

Where:

H = absolute humidity in grains of water/lb dry air

T = Temperature (°F)

Both of the correction factors are capped at a value of 2.19.

Correction factors were calculated using weather information recorded by the weather station attached to the RSD van. Water vapor grains per lb were determined using the temperature, relative humidity and barometric pressure:

$$\begin{aligned} \text{Saturated Vapor Pressure} = & (-4.14438 \times 10^{-3} + 5.76645 \times 10^{-3} \times [\text{Temp } ^\circ\text{F}] - 6.32788 \times 10^{-5} \times \\ & [\text{Temp } ^\circ\text{F}]^2 + 2.12294 \times 10^{-6} \times [\text{Temp } ^\circ\text{F}]^3 - 7.85415 \times 10^{-9} \times [\text{Temp } ^\circ\text{F}]^4 + 6.55263 \times 10^{-11} \times \\ & [\text{Temp } ^\circ\text{F}]^5) \times 25.4 \end{aligned}$$

$$\text{Grains per lb} = (43.478 \times [\text{Relative Humidity}] \times [\text{Saturated Vapor Pressure}]) / ((([\text{Barometric pressure Hg mm}] - ([\text{Saturated Vapor Pressure}] \times [\text{Relative Humidity}] / 100)))$$

The vehicle NO_x emissions reported in Section 5 have been adjusted for humidity.

3 VEHICLE EMISSION DATA COLLECTED

3.1 RSD Sample Quantity

3.1.1 Data Collection Summary

The number of light-duty vehicles registered in the Northern I/M area (Lake and Porter counties) is approximately 450,000. The requirement of a 1% sample of subject vehicles therefore requires 4,500 measurements.

In total, 31,844 RSD measurements were made from April 17th through August 6th 2009. These statistics include duplicate instances of the same vehicle where the vehicle has been measured by RSD more than once. Data were collected from eight sites.

Table 3-1: Remote Sensing Measurements Summary

Item	Quantity	%
RSD valid HC, CO, NOx, Speed & Acceleration and in desired operating mode (VSP)	31,844	
Additional screening:		
NOx values less than -250 ppm	2	0.0%
Valid and in desired VSP range after screening	31,846	
Valid with readable plate	27,931	87.7%
Of which:		
Indiana	23,662	84.7%
Out of State License Plate	4,269	15.3%
Of which:		
Matched to BMV Lake/Porter Registrations	16,709	70.6%

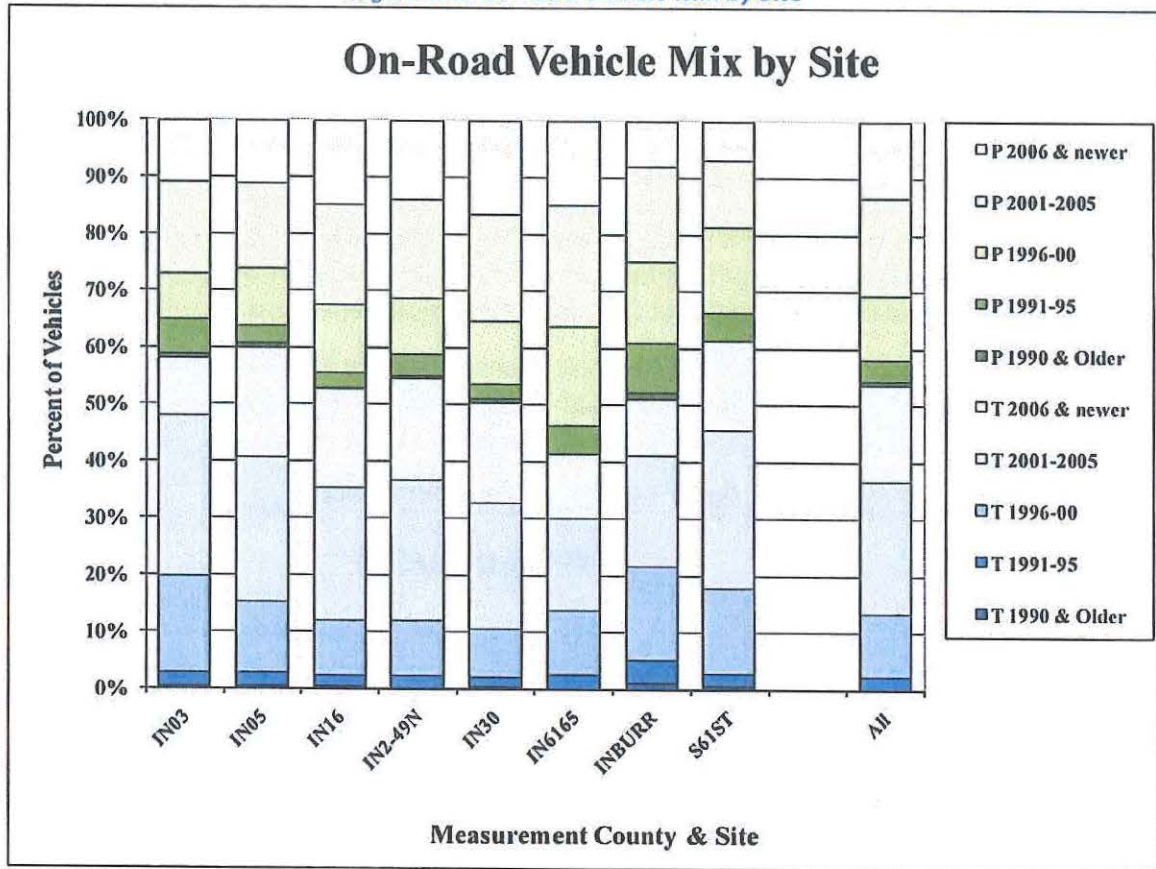
3.1.2 Vehicle Composition

Vehicle type was identified from the VIN for matched plates. These were determined to be:

- Passenger vehicles 46%
- Trucks 54%

Vehicles were then divided into five model year ranges to determine if the mix of vehicles by type and model year was consistent among sites. Figure 3-1: On-road Vehicle Mix by Site shows differences in the proportion of passenger vehicles and the age of vehicles.

Figure 3-1: On-road Vehicle Mix by Site



3.2 On-road Fleet Emission Distribution

The following four charts show the emission percentiles for HC, CO, NO and UV Smoke for all Indiana plate vehicles measured in the 5 to 22 kilowatts per metric ton (kW/t) range. Pollutant values are shown on the left y-axis.

Upper black lines indicate the % of the pollutant (right y-axis) produced by a given % of vehicles (x-axis) when rank ordered from highest to lowest. This indicates 20% of vehicles account for 85% of CO, 90% of HC, 90% of NO and 70% of PM (UV Smoke) emissions.

The vast majority of vehicles have low emissions and contribute little to regional pollution. Ten-to-twenty percent of vehicles have much higher emissions and emit over 70-90% of the on-road light-duty vehicle emissions.

Figure 3-2: CO Emissions Distribution

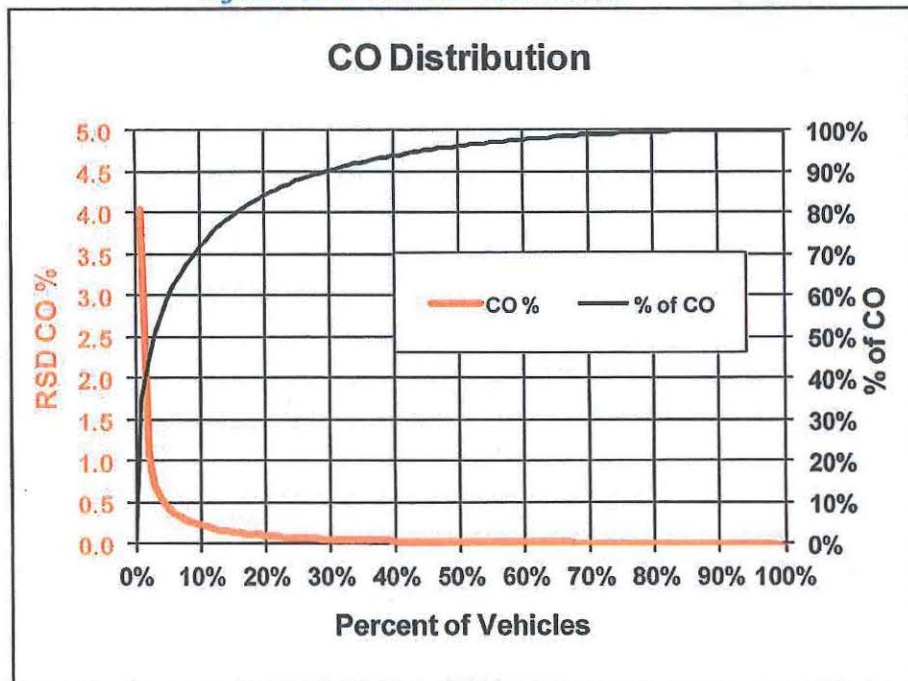


Figure 3-3: HC Emissions Distribution

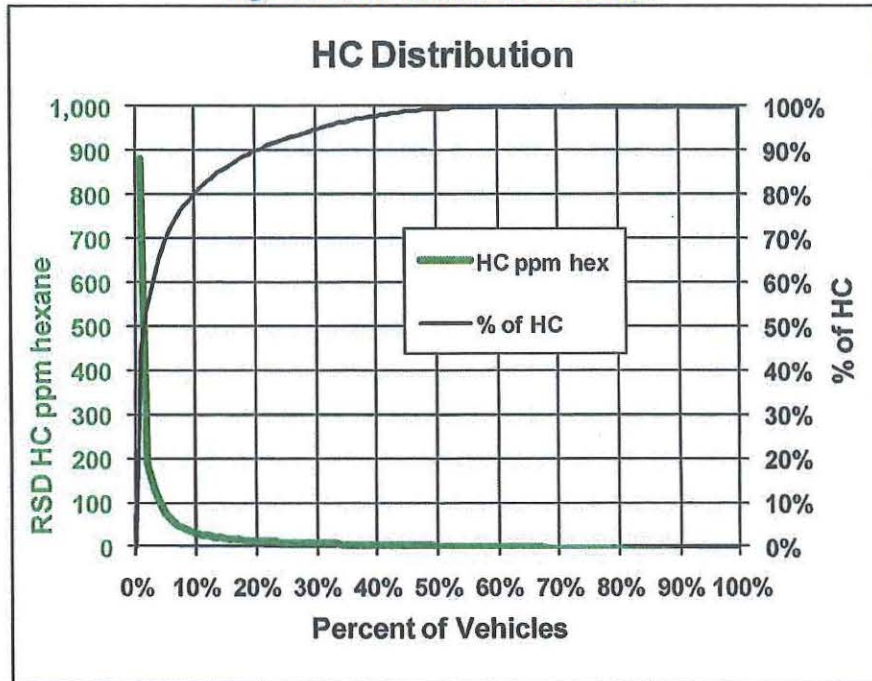


Figure 3-4: NO Emissions Distribution

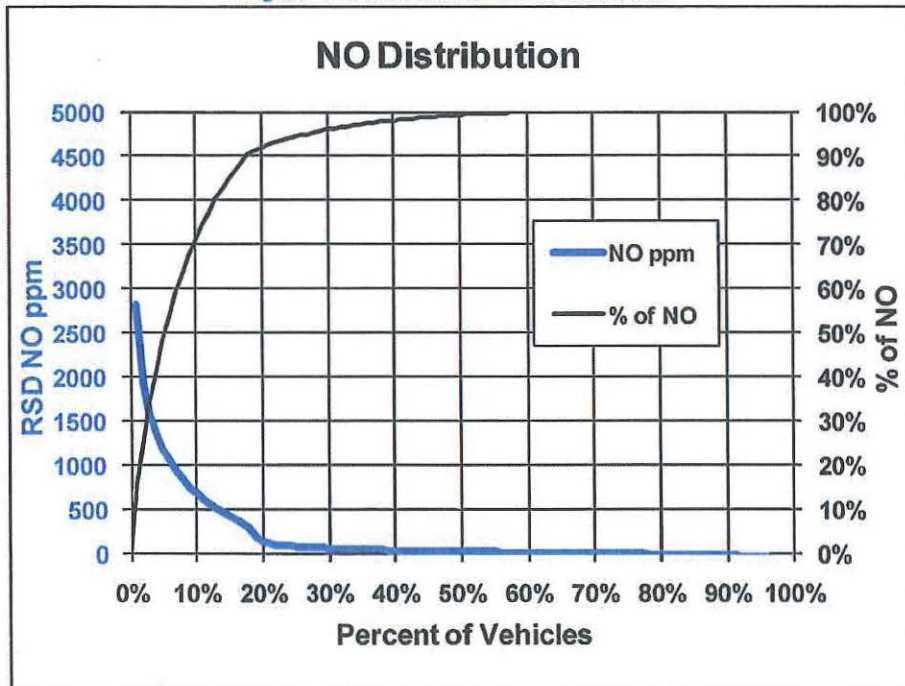
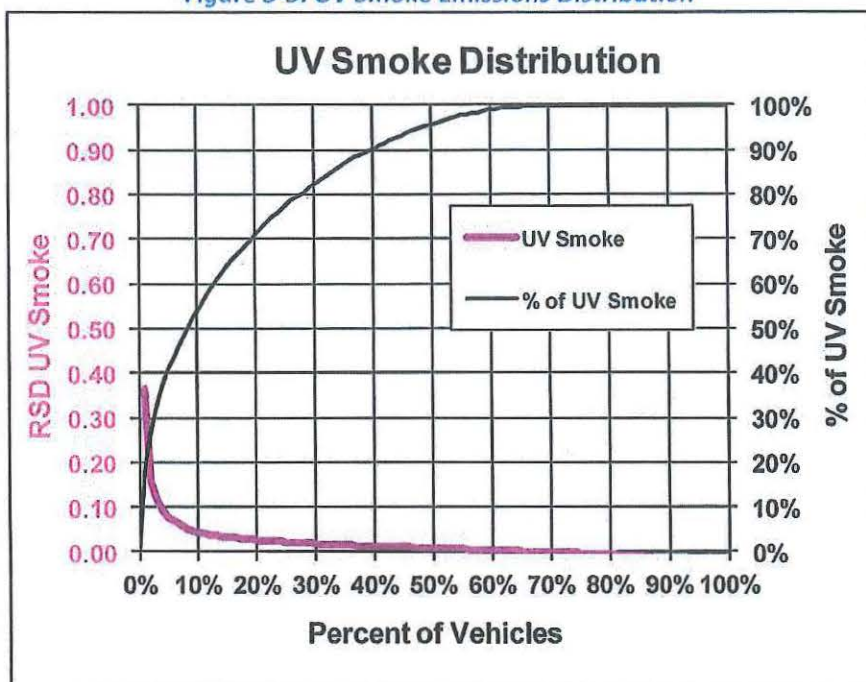


Figure 3-5: UV Smoke Emissions Distribution



3.3 Emissions by Registered Jurisdiction

In this section, emissions of vehicles registered in the different areas are compared (independent of where they were seen driving). Table 3-2 and Figures 3-7 to 3-10 show mean HC, CO, NO and Smoke measurements by jurisdiction. Data about the vehicles such as their type and model was only available for vehicles registered in Lake and Porter counties. Therefore, the results shown are for all vehicles from a jurisdiction and it is not known whether the vehicles from the different jurisdictions have a similar mix of vehicles by age and type. Thus one cannot draw many conclusions from the charts.

To assess whether the comparison of emission values may be affected by different vehicle operating conditions, the average vehicle specific power for each group is plotted in Figure 3-6. Average VSP is similar for all jurisdictions.

Vehicles known to be registered in Lake and Porter counties had lower HC and CO emissions than Indiana plates that were not matched to a Lake County or Porter County registration. Vehicles from other states had similar emissions. Illinois vehicles had higher CO and NO_x than vehicles known to be registered in Lake and Porter counties.

Most notable is that Indiana plated vehicles not identified as registered in Lake and Porter counties had over 30% higher average emissions across all pollutants, made up one quarter of the vehicles operating within Lake and Porter counties and emitted more than one third of the measured emissions. This merits additional investigation to verify that, for example, vehicle owners moving into the region are properly registering their new address and that owners of vehicles failing I/M are not transferring their registration to other counties.

Figure 3-6: Jurisdiction of Vehicles Measured

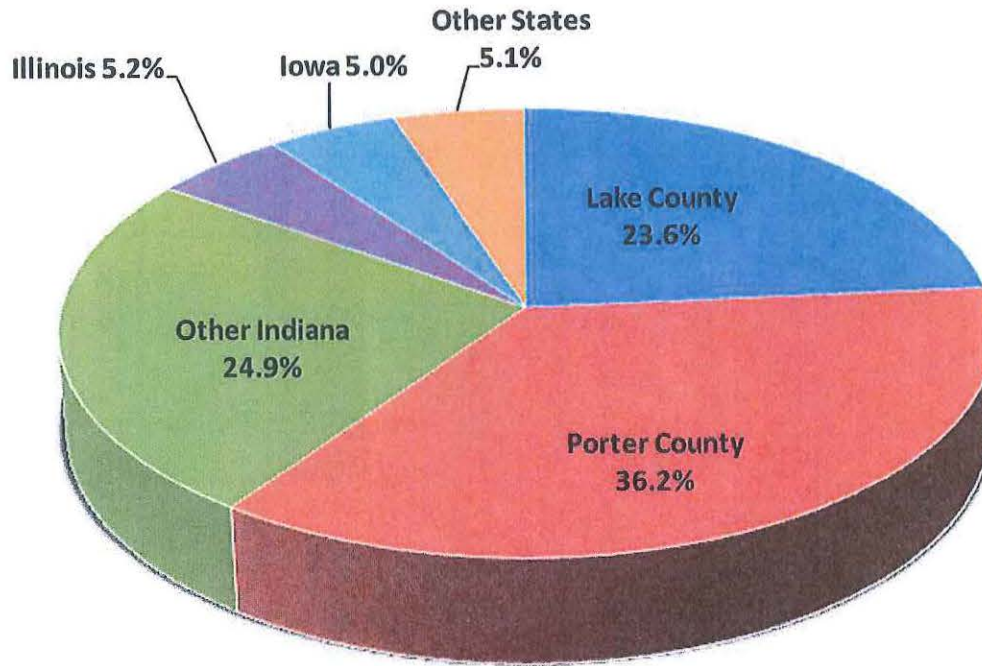


Table 3-2: Emissions by Jurisdiction

Jurisdiction	N	CO	HC	NOx	Smoke	VSP
Lake County	6,602	0.11	17	166	0.013	13.2
Porter County	10,107	0.09	10	145	0.014	14.7
Other Indiana Counties	6,951	0.16	25	228	0.021	14.1
Illinois	1,454	0.12	16	172	0.016	13.6
Iowa	1,395	0.10	13	172	0.013	14.0
Other States	1,420	0.11	15	161	0.016	14.3
Total	27,929	0.11	16	174	0.016	14.1

Figure 3-7: RSD HC Emissions by Jurisdiction

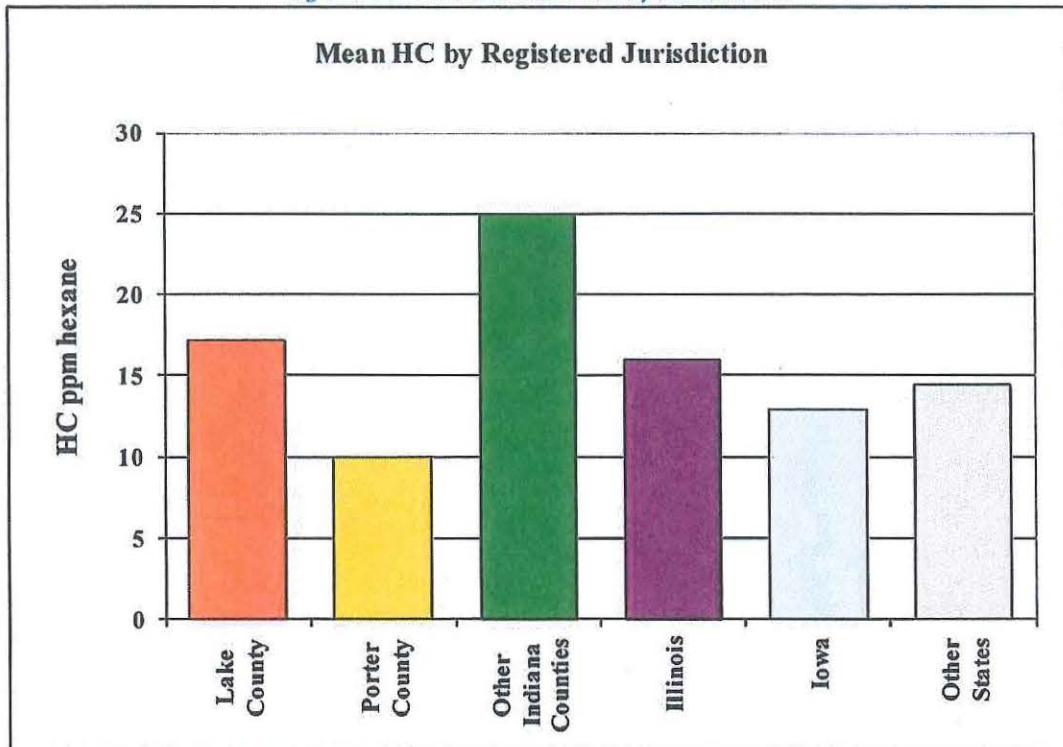


Figure 3-8: RSD CO Emissions by Jurisdiction

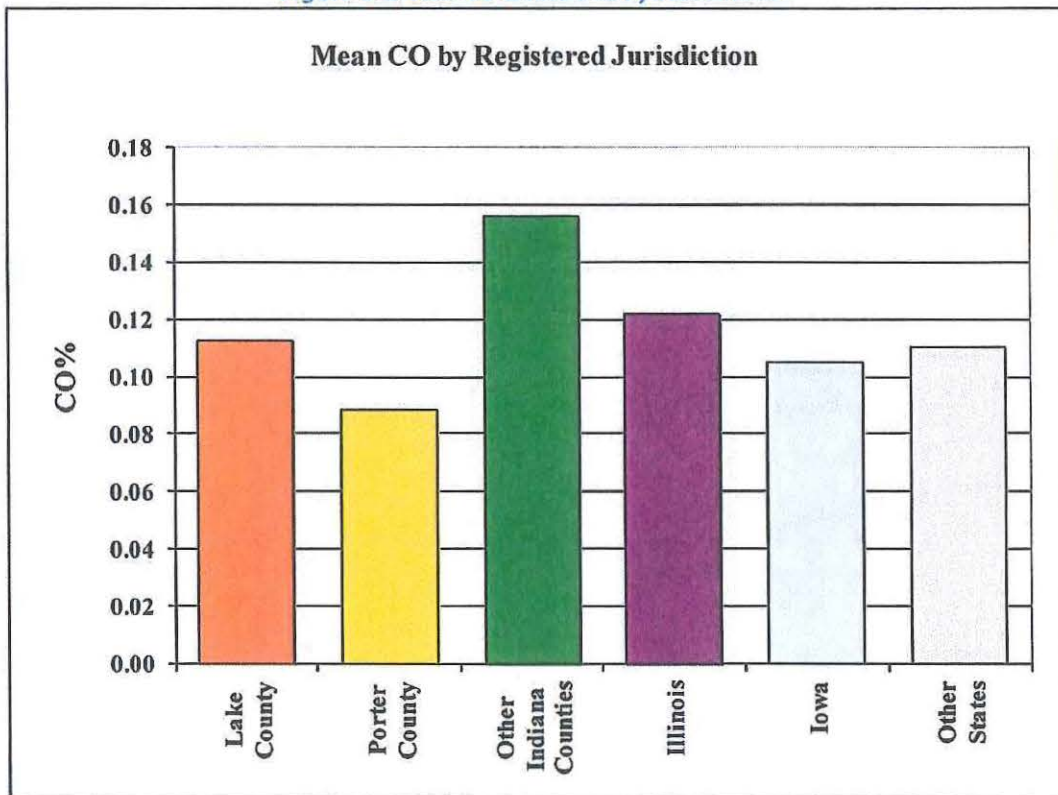


Figure 3-9: RSD NO_x Emissions by Jurisdiction

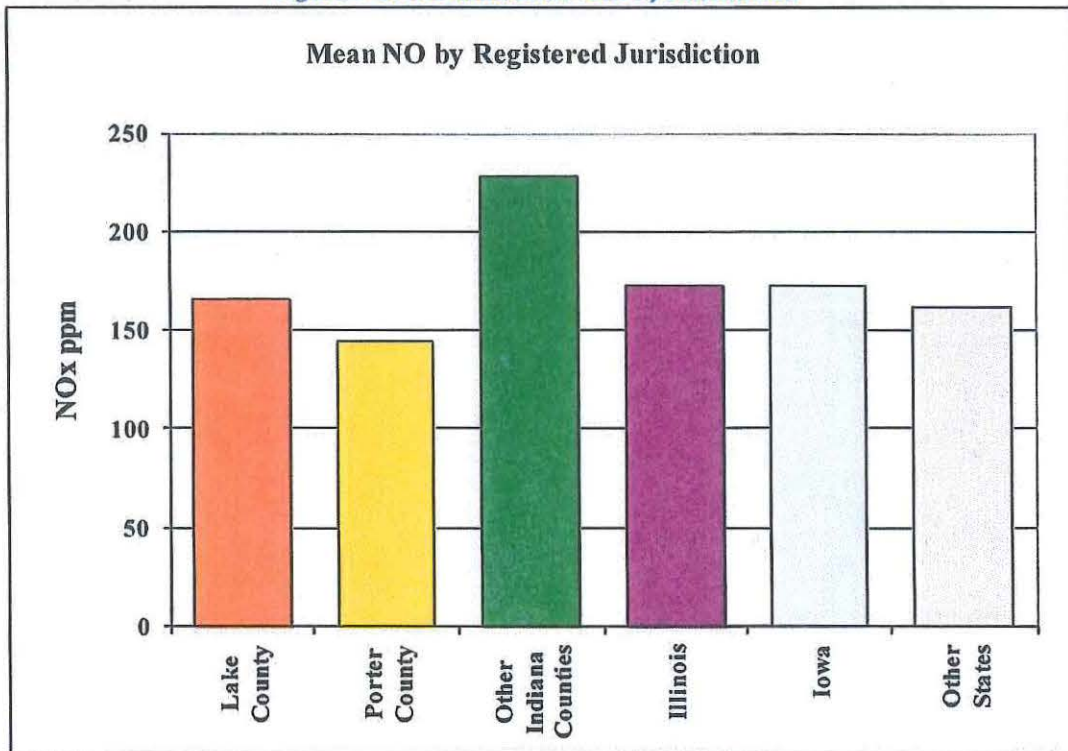


Figure 3-10: RSD UV Smoke Emissions by Jurisdiction

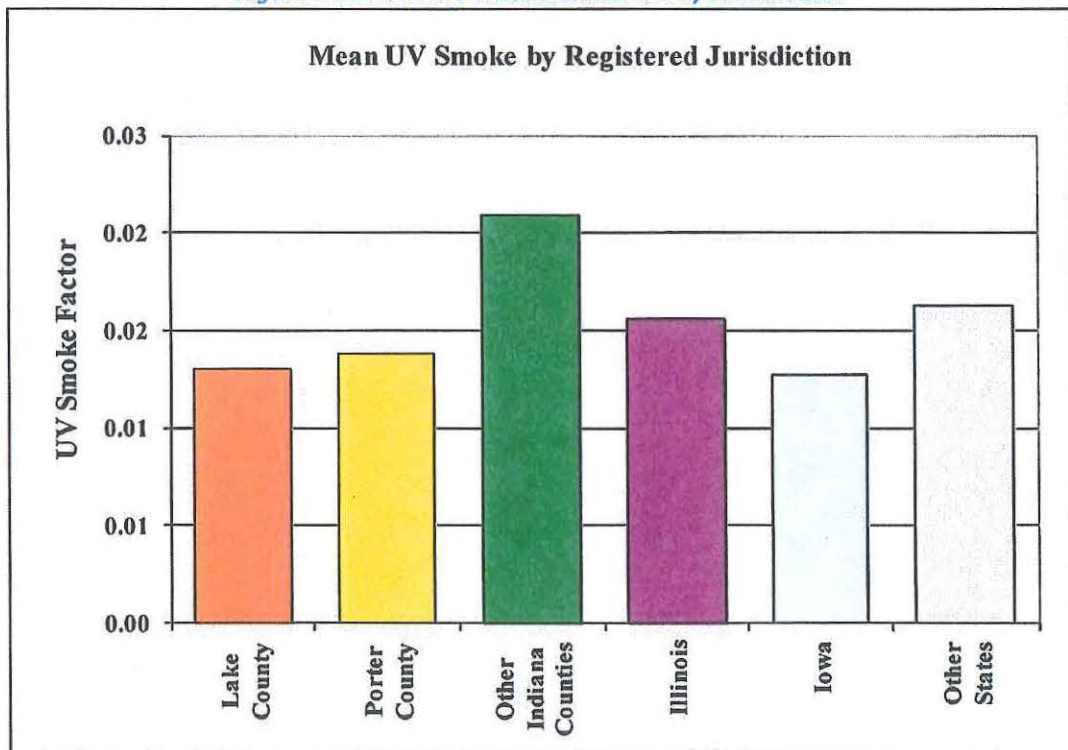
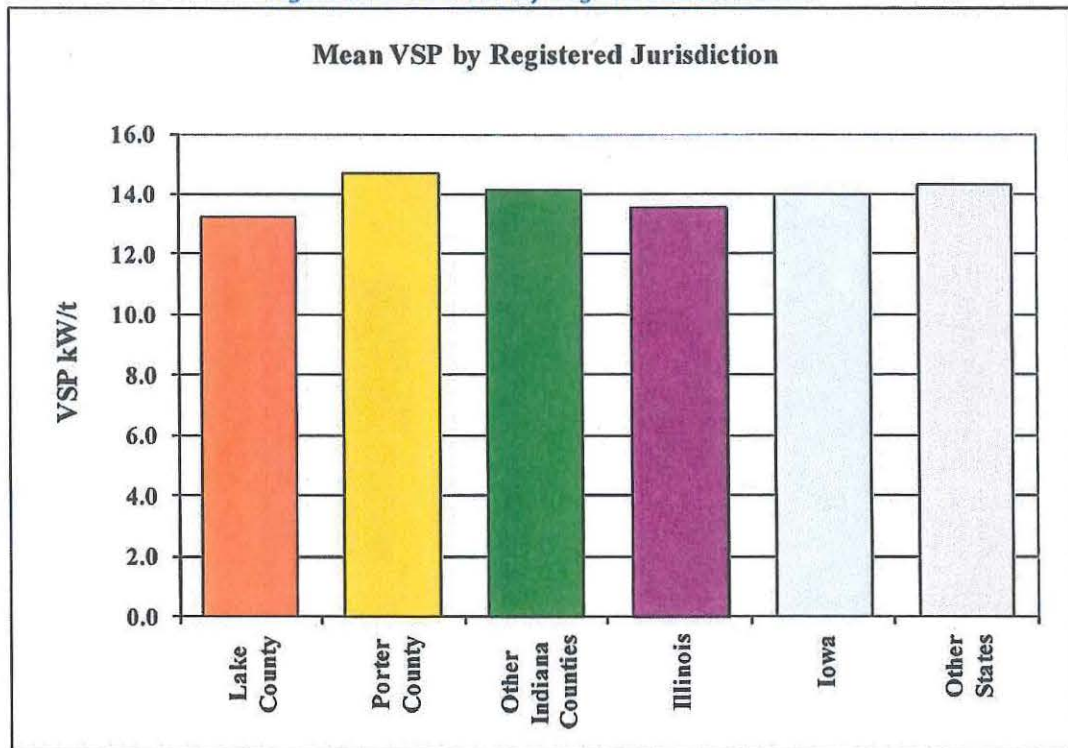


Figure 3-11: RSD VSP by Registered Jurisdiction



3.4 Emissions by Type and Model Year

Emissions for different models by 5-year bins are shown in Figure 3-12 for passenger vehicles and light-duty trucks.

The difference in average emissions between the oldest and newest models is extreme. 1985 and older models had the highest emissions. 1986-1995 models were many times dirtier than newer models. Even 1996-2000 models had emissions several times those of 2006-2010 models. Older model trucks had higher emissions than passenger vehicles.

Figure 3-12: Emissions by Vehicle Type and Model Year

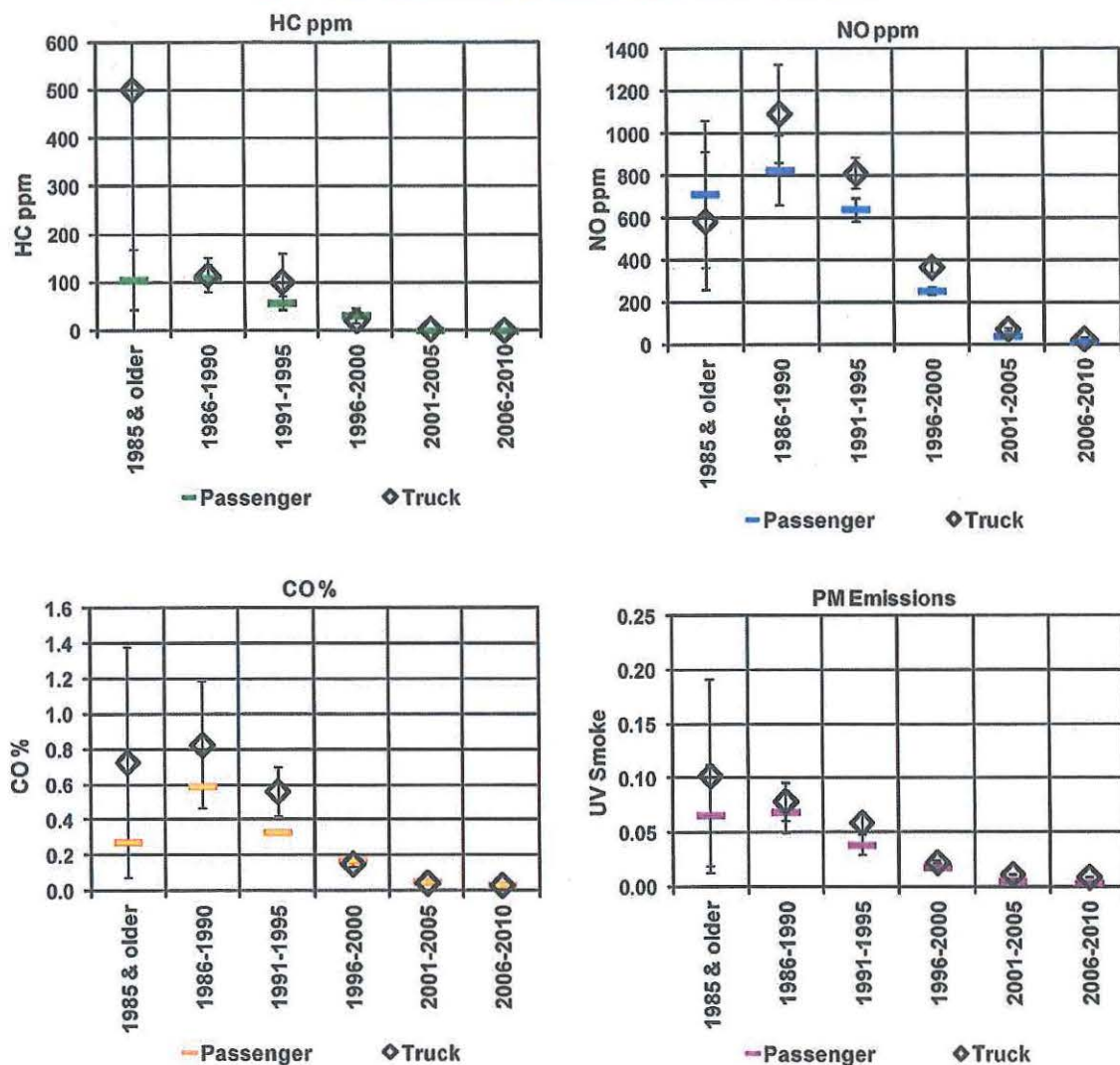


Figure 3-13 compares average emissions of passenger vehicles in Lake and Porter counties. Older models in Porter County may have higher HC and NO_x emissions. A larger on-road sample is required to confirm the differences are statistically significant.

Figure 3-13: Lake and Porter Counties Passenger Vehicle Emissions

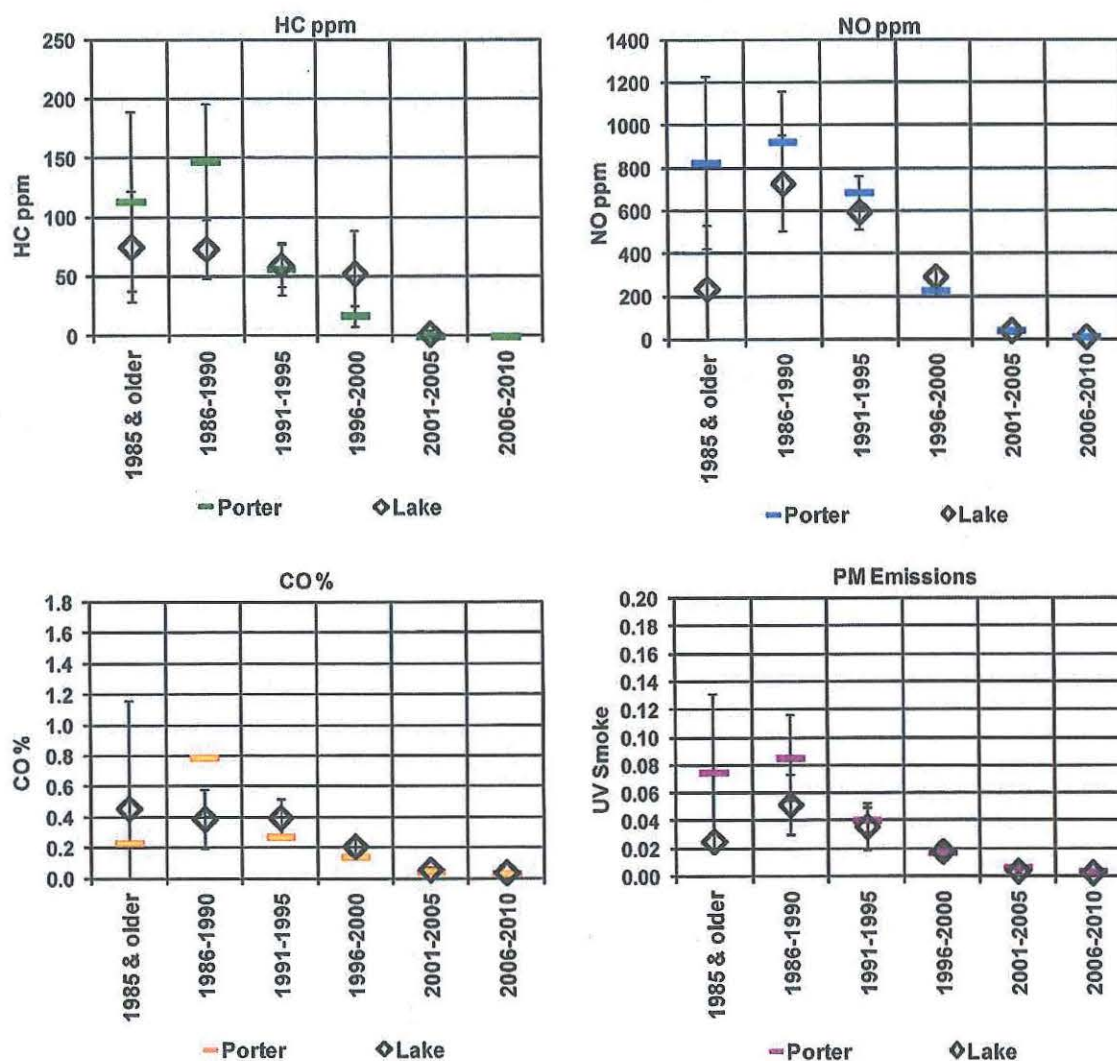
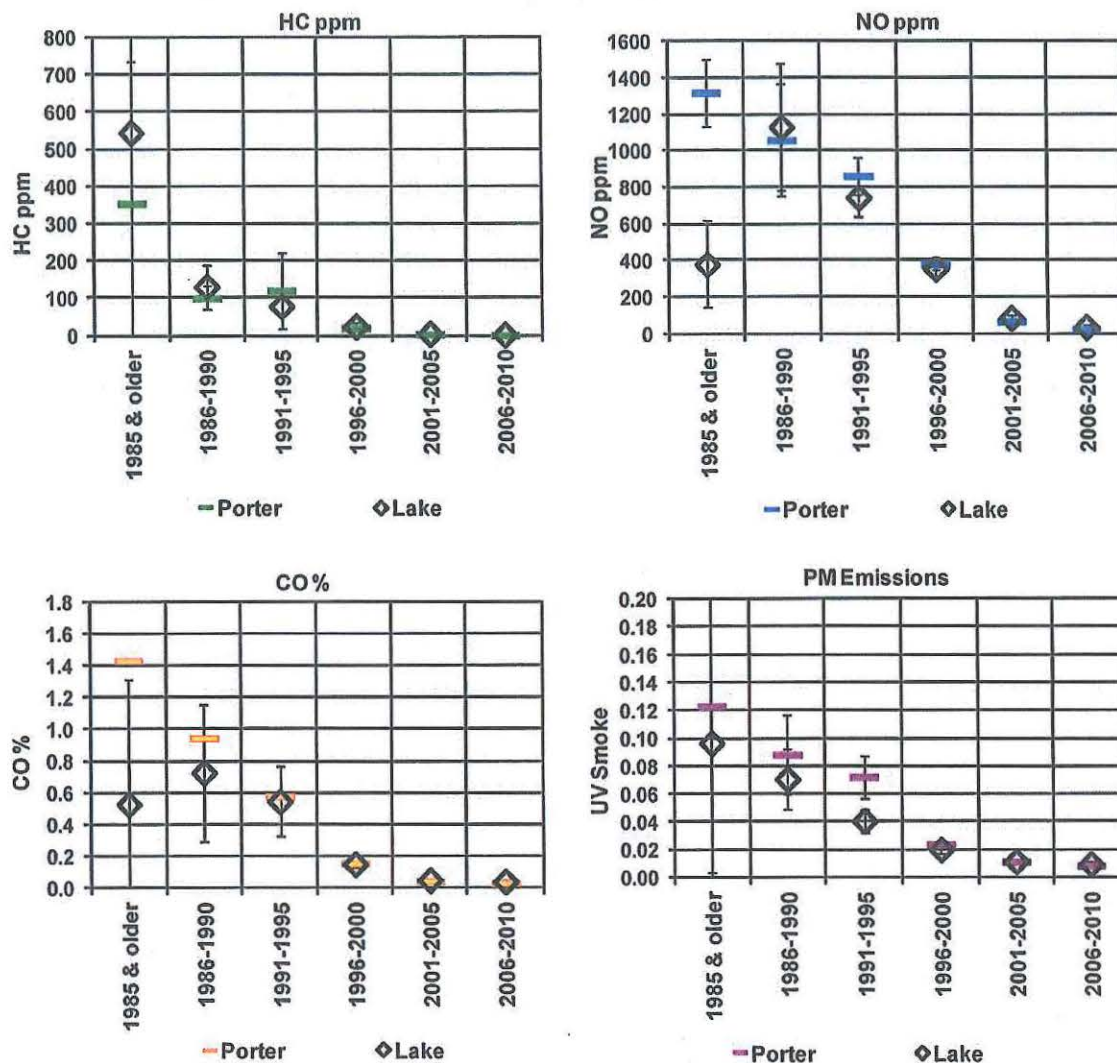


Figure 3-14 compares average emissions of light-duty trucks in Lake and Porter counties. Differences in emissions in the two counties are smaller than for passenger vehicles. Note the truck chart scales span a wider range than the passenger vehicle charts for HC and NO.

Figure 3-14: Lake and Porter Counties Light-Duty Truck Emissions



The relationship between UV Smoke Factor and mass for gasoline PM estimates is approximate. Gasoline particulates have different characteristics than diesel particulates and, as noted earlier, an accurate characterization of typical gasoline vehicle particulates and their mass correlation to RSD UV Smoke Factor is the subject of continuing research.

3.5 Emission Contributions by Type and Age

Table 3-3 shows the split between passenger vehicles and light-duty trucks in numbers and their estimated emissions contributions. Light-duty trucks were 53.8% of vehicles observed compared to 46.2% passenger vehicles.

Relative emission contributions in Table 3-3 were calculated using a simplified approach: emission contribution is proportional to the number of measurements times the emission levels. The number of RSD measurements of a class of vehicles has been demonstrated in studies⁶ to be proportional to the VMT of the class, i.e. the greater the miles driven by a class of vehicle the more often its members are observed on-road. The mass of exhaust per mile is inversely proportional to fuel economy, i.e. better fuel economy equated to a smaller mass of exhaust emissions per mile. Mass emissions are consequently proportional to the average emission concentrations times the number of observations divided by fuel economy. This allows the relative share or contribution of emissions produced by different classes of vehicles to be calculated.

Average fuel economies of 23 mpg for passenger vehicles and 17 mpg for light-duty trucks were used in the calculations. This is reasonable if fuel economy is similar across all age groups (fuel economy has changed little since the early 1980's). More accurate estimates could be obtained by determining and applying the individual fuel economy for each vehicle.

Using the simple approach described above, light-duty trucks are estimated to contribute 57.6%, 56.6%, 63.1% and 67.9% of the light-duty vehicle sector CO, HC, NO and PM (UV Smoke) emissions. It is assumed that UV Smoke is a reasonable measure of total particulate emissions.

Table 3-3: Vehicles and Emission Contributions by Type and Age

Type	Vehicles	Emission Contributions			
		CO	HC	NO	PM
Passenger	46.2%	42.4%	43.4%	36.9%	32.1%
Truck	53.8%	57.6%	56.6%	63.1%	67.9%

Within passenger vehicles, Table 3-4 shows that 1986-1995 models were 9.4% of measurements contributing 43.2% of HC and 35.5% of NO. In contrast, 2006-2010 models were 29% of measurements contributing only 0.9% of HC and 25.4% of NO.

The lower section of Table 3-4 shows the light-duty trucks measured were predominantly 2001 and newer models (74.15%) contributing 16.2% of light-duty truck HC and 49.8% of light-duty truck NO.

Figure 3-15: Passenger and Light-Duty Truck Emission Contributions

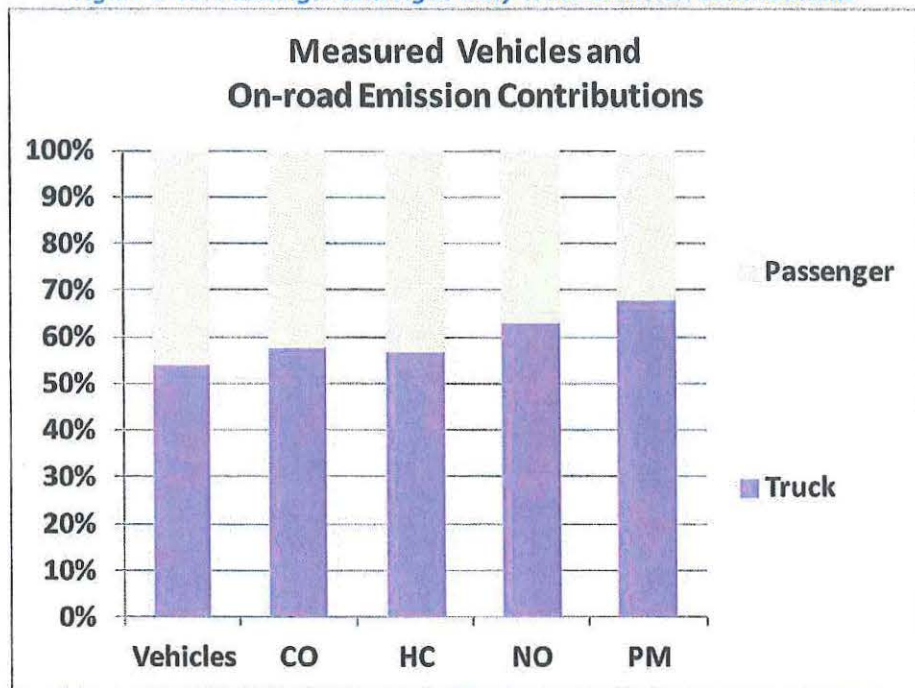


Table 3-4: Vehicles and Emission Contributions by Age

Model Years	Vehicles	Passenger Vehicle Emission Contributions			
		CO	HC	NO	PM
1985 & Older	0.2%	0.5%	1.5%	1.0%	1.2%
1986-1990	1.3%	7.4%	10.1%	7.4%	8.0%
1991-1995	8.1%	25.7%	33.1%	35.9%	27.5%
1996-2000	24.2%	39.0%	54.3%	42.4%	37.9%
2001-2005	37.2%	18.0%	0.9%	10.6%	17.4%
2006-2010	29.0%	9.4%	0.0%	2.6%	8.0%
Total	100.0%	100.0%	100.0%	100.0%	100.0%

Model Years	Vehicles	Light Truck Emission Contributions			
		CO	HC	NO	PM
1985 & Older	0.1%	0.8%	4.2%	0.4%	0.7%
1986-1990	0.7%	6.4%	6.9%	4.9%	3.6%
1991-1995	4.2%	26.0%	36.1%	21.5%	16.2%
1996-2000	20.5%	34.4%	36.6%	47.6%	29.7%
2001-2005	43.2%	21.5%	13.2%	20.2%	31.9%
2006-2010	31.3%	10.9%	3.0%	5.4%	17.9%
Total	100.0%	100.0%	100.0%	100.0%	100.0%

Figures 3-16 and 3-17 further illustrate the split of vehicles and contributions within the passenger vehicle and light-duty truck sectors.

Figure 3-16: Passenger Vehicle Emission Contributions by Age

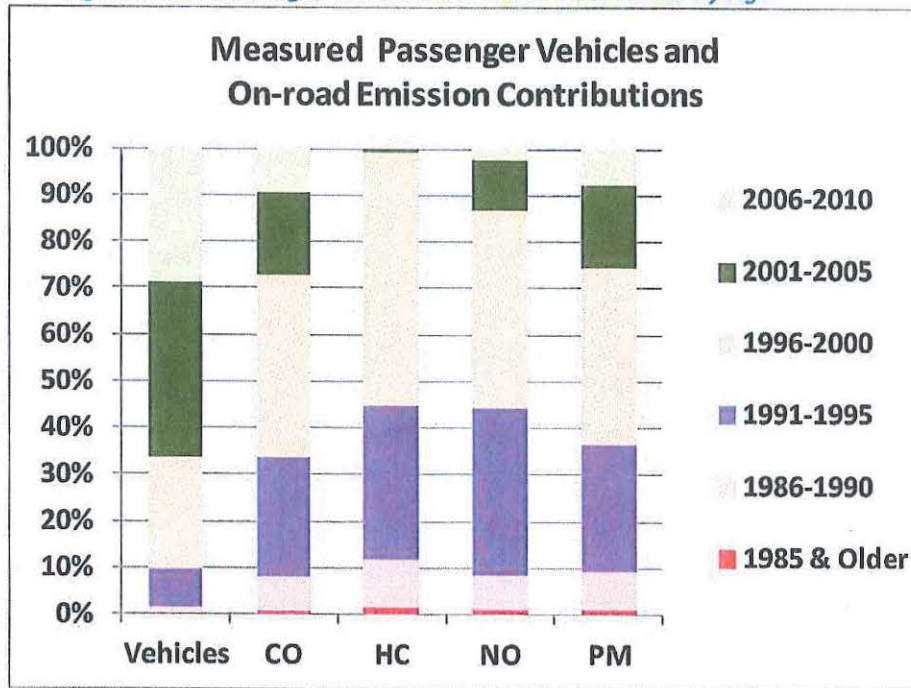
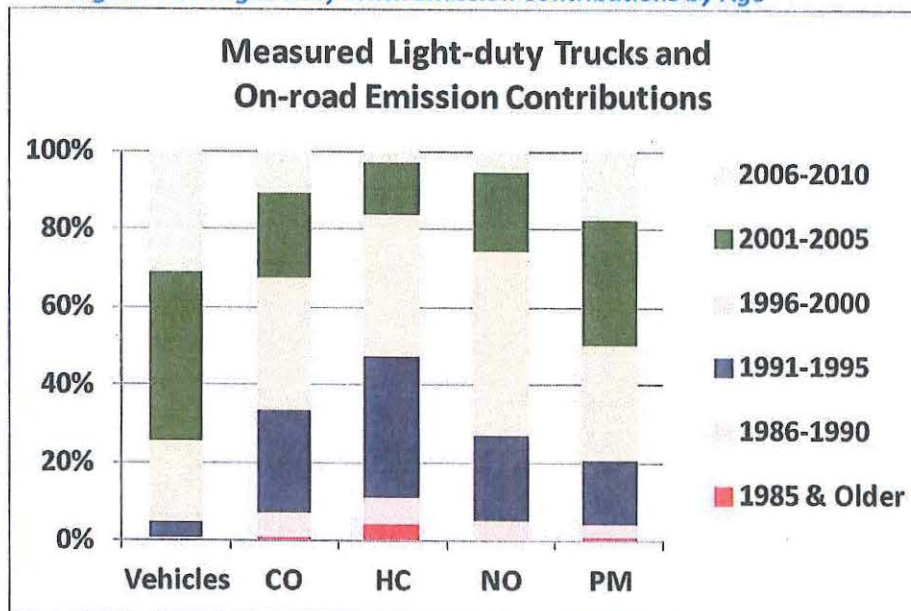


Figure 3-17: Light-Duty Truck Emission Contributions by Age



4 I/M STATUS OF ON-ROAD VEHICLES

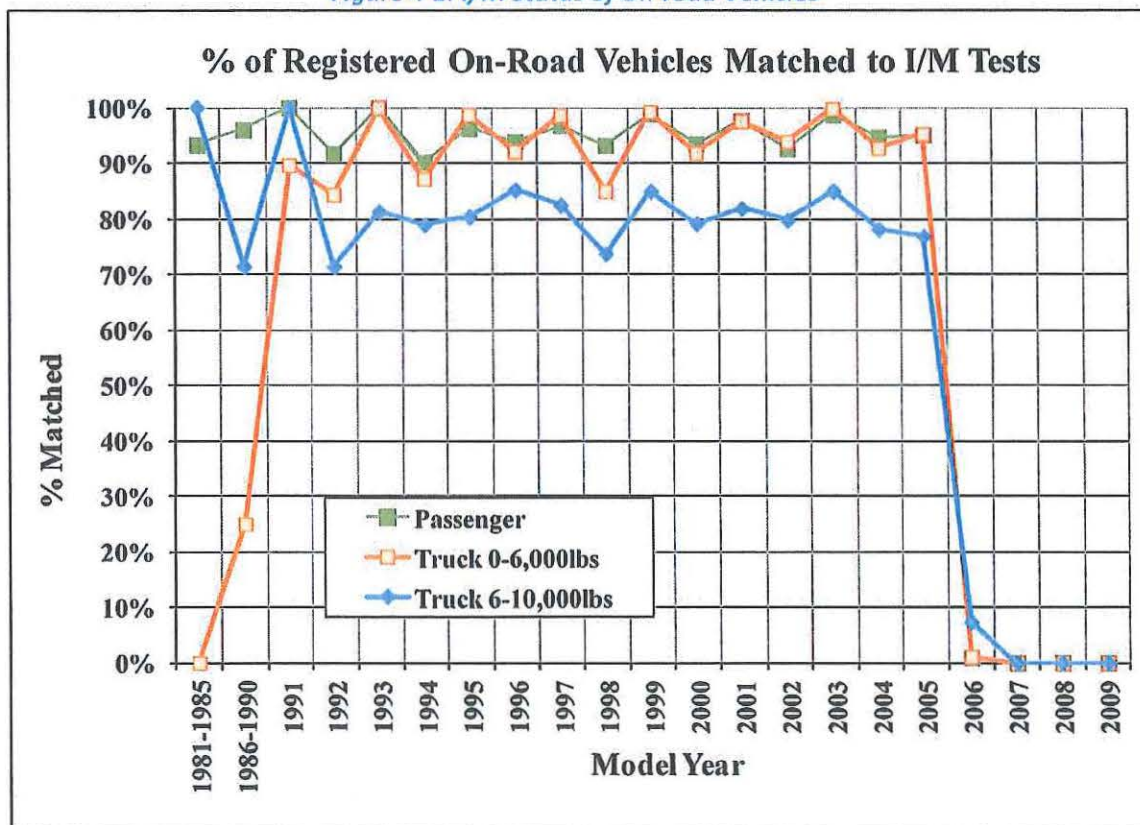
ESP compared on-road emissions to the previous I/M inspection result for gasoline and diesel powered vehicles registered within the two counties. I/M records from 2007-2009 were analyzed to extract the date and the result of the last I/M test.

Figure 4-1: I/M Status of On-road Vehicles summarizes the status of vehicles observed on-road by model year. Vehicles as old as 1976 models were subject to inspection but the oldest model vehicles identified as being registered to Lake or Porter counties were 1981 models.

Because of the four-year new model exemption, 2006 and newer models were not required to have obtained an emissions inspection at the time the data were reviewed.

The upper orange and green lines show that 95.5% of 1981-2005 passenger models and 94.5% of trucks 6000 lbs GVWR or less had obtained at least one inspection between 1/1/2007 and 12/31/2009. The equivalent rate for trucks between 6000 and 10,000lbs GVWR and greater was 80.3%. Some of these are exempt from testing as the upper weight limit on the inspection requirement is 9000lbs. In addition, diesel vehicles are exempt.

Figure 4-1: I/M Status of On-road Vehicles



There is an obvious biennial pattern in the results showing the rate of matched tests was higher for odd model year vehicles. Odd model-year vehicles were covered by two of the years of test data reviewed for matched inspections (2007 & 2009), which may account for the higher

percentage. But this does not explain why matching tests were not found among 2008 tests for about 10% of the even model-year vehicles. This result will be reexamined in the 2011 survey.

Figure 4-2: I/M Status of On-road Vehicles by County shows on-road vehicles with test matched records by county for the 1976-2005 models by fuel, type (P-passenger, T-truck) and truck weight class (1 or 2). A few diesel powered vehicles had inspection records although they were exempt. Figure 4-3 confirms that inspection rates were similar in the two counties. There was some difference for the 6,000 to 10,000lb GVWR truck category. In Lake County 85% of 6,000-10,000lb GVWR trucks were inspected vs. 82% in Porter County.

Figure 4-2: I/M Status of On-road Vehicles by County

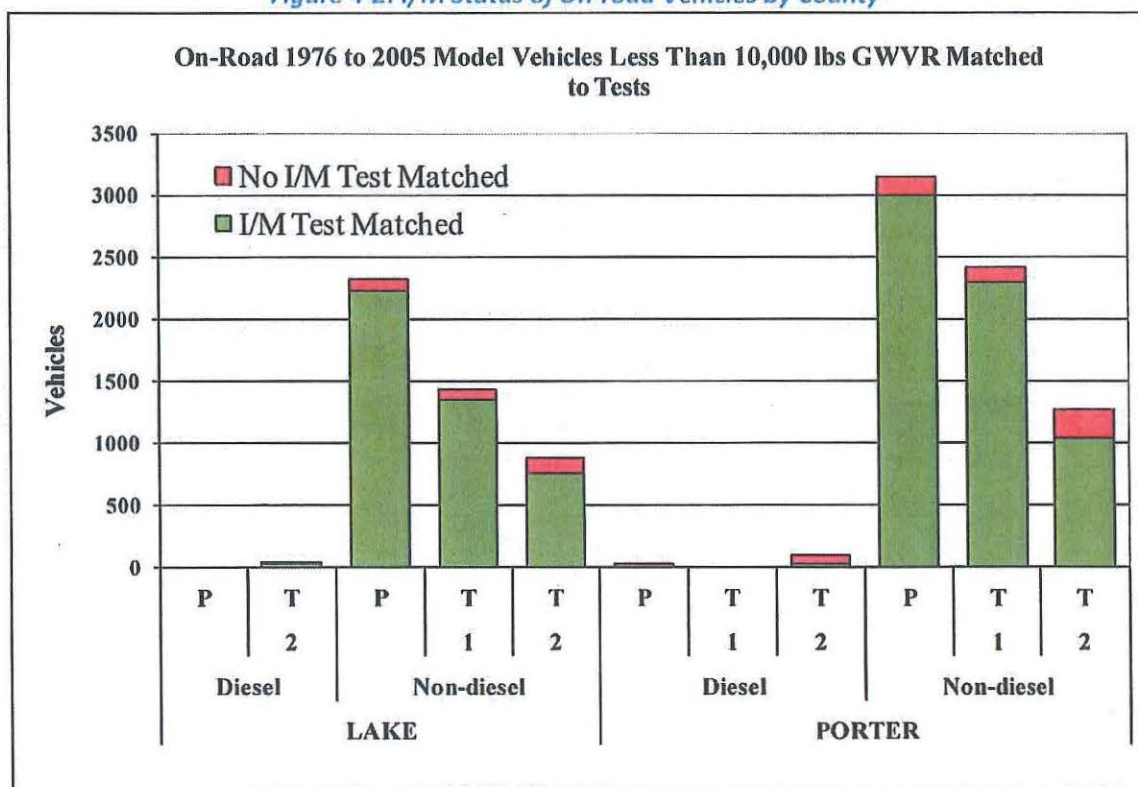
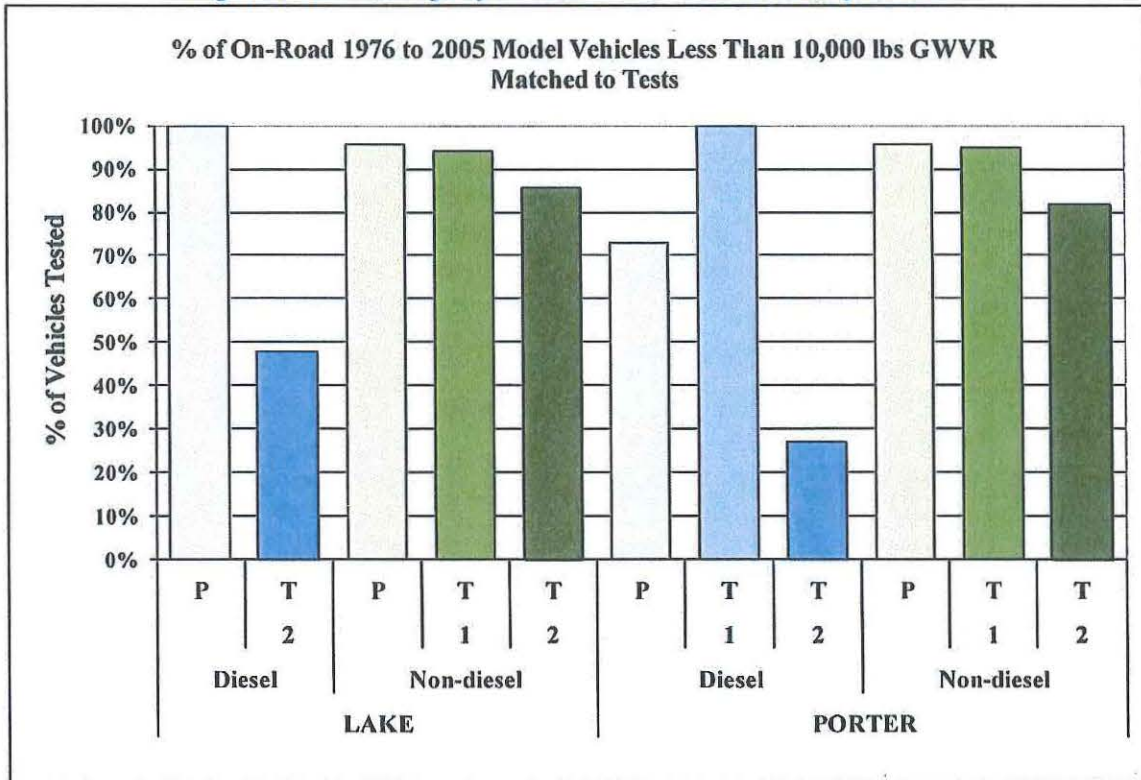


Figure 4-3: Percentage of On-road Vehicles Matched to I/M Tests



5 High Emitters

For this survey, high emitters were identified using cutpoints listed in Table 5-1, which have been used to identify high emitters in Maryland surveys. Vehicles were divided into three GVWR classes: 1) 0 to 6,000 lbs, 2) 6,001 to 10,000 lbs, and 3) over 10,000 lbs. The cutpoints for HC in this table are specified in ppm HC hexane, which is consistent with most I/M inspection equipment used to measure tailpipe concentrations. Remote sensing NOx emissions were corrected for humidity as described in Section 2 before being compared to the high emitter standards.

Table 5-1: On-road High Emitter Cutpoints

Year	GVWR ≤ 6,000 lbs			GVWR 6,001-10,000 lbs			GVWR 10,001+ lbs		
	HC (ppm)	CO (%)	NOx (ppm)	HC (ppm)	CO (%)	NOx (ppm)	HC (ppm)	CO (%)	NOx (ppm)
1977	700	7	2,718	700	7	2,557	700	7	5,000
1978	645	7	2,718	700	7	2,557	700	7	5,000
1979	600	6	2,718	700	7	2,045	700	7	5,000
1980	330	2.6	2,718	525	7	2,045	700	7	5,000
1981	330	1.8	2,718	375	4.5	2,045	700	7	5,000
1982	330	1.8	2,718	330	3.8	2,045	700	7	5,000
1983	330	1.8	2,718	330	2.3	2,045	700	5.3	5,000
1984	264	1.8	2,252	311	1.8	1,969	660	4.5	4,500
1985	264	1.8	2,252	292	1.8	1,969	660	4.5	4,500
1986	264	1.8	2,252	292	1.8	1,969	420	3.8	4,500
1987	264	1.8	2,252	187	1.8	1,969	330	1.8	4,500
1988	264	1.8	1,243	180	1.8	1,917	330	1.8	4,500
1989	264	1.8	1,243	180	1.8	1,917	330	1.8	4,500
1990	264	1.8	1,243	180	1.8	1,917	330	1.8	4,500
1991	208	1.8	1,087	168	1.8	1,457	330	1.8	4,000
1992	208	1.8	1,087	168	1.8	1,457	330	1.8	4,000
1993	208	1.8	1,087	168	1.8	1,457	330	1.8	4,000
1994	208	1.8	1,087	168	1.8	1,457	330	1.8	4,000
1995	208	1.8	1,087	168	1.8	1,457	330	1.8	4,000
1996+	100	1.0	893	168	1.0	1,457	330	1.8	3,600

In order to be considered a high emitter in Maryland, a vehicle was required to have 2 or more readings that exceeded the standards for the same pollutant on different days. If the standard is exceeded by less than the tolerance of the RSD unit, a third measurement is required for confirmation.

Some 2,590 vehicles had two or more valid remote sensing measurements on different days within the normal VSP operating range of 3 to 22 kW/t. Sixty (2.3%) of these exceeded the cutpoints on both of their last two measurements for the same pollutant having average emissions that were 22 times higher for HC, and 9 times higher for CO and NOx than the average emissions of all vehicles with two measurements.

Forty-five percent of high emitters were 1995 and older models and 42% were 1996-1999 models.

Vehicles with out-of-state registrations were not considered in the high emitter analysis because their type and model year was unknown. Correct high emitter cutpoints cannot be selected without this information.

As summarized in Table 5-2, under the Maryland rules, 31 of the 60 suspected high emitters required additional confirmation by a third measurement. Those not requiring a third measurement are listed in Table 5- 3. Those requiring a third measurement are listed in Table 5-4.

Table 5-2: High Emitter Summary

Pollutant Exceeded	High Emitter	Suspected	Total
HC only	2	1	3
CO only	0	0	0
NO only	19	27	46
HC & CO	5	1	6
HC & NOx	2	2	4
CO & NOx	0	0	0
All	1	0	1
Total	29	31	60

Third measurements were available on 16 of the 31 suspected high emitters and these are listed in Table 5-5. Twelve were confirmed and four were not. Of the four not confirmed, one may have failed in the 40 days between the oldest measurement and the two most recent measurements, and two others had elevated emissions on their third measurement but did not exceed the standard.

Table 5-3: High Emitters

Year	Type	Make	Model	GVW Code	Fuel	Registration County	Date		HC Values			CO Values			NOx Values		
							Last	Prev	Std	Last	Prev	Std	Last	Prev	Std	Last	Prev
High Emitters (Last two measurements both exceed the emissions standards for at least one pollutant by more than the RSD tolerance).																	
1988	P	HOND	CIVIC CRX HF 1.5 LITRE		G	POR	13-Jul-09	30-Jun-09	264	286	521	1.8	6.6	5.4	1,243	496	548
1990	T	CHEV	C1500	1	G	POR	14-Jul-09	25-Jun-09	264	120	18	1.8	0.1	0.1	1,243	1,997	2,359
1990	P	CHEV	CORSICA LT		G	LAK	16-Jun-09	15-Jun-09	264	178	167	1.8	0.5	0.4	1,243	2,584	2,053
1991	T	CHEV	ASTRO VAN	1	G	LAK	19-May-09	05-May-09	208	209	325	1.8	7.8	5.6	1,087	178	87
1991	T	PLYM	GRAND VOYAGER SE	1	G	POR	05-Aug-09	04-Aug-09	208	90	587	1.8	0.3	0.4	1,087	2,093	3,778
1991	P	CHRY	LEBARON		G	POR	29-Jun-09	26-Jun-09	208	176	78	1.8	0.6	0.2	1,087	2,156	2,391
1993	T	DODG	DAKOTA	1	G	POR	15-Jul-09	14-Jul-09	208	110	196	1.8	0.6	0.8	1,087	1,686	1,342
1993	T	JEEP	CHEROKEE COUNTRY	1	G	POR	27-Jul-09	21-Jul-09	208	60	59	1.8	0.4	0.5	1,087	1,938	2,053
1993	P	BUIC	LESABRE CUSTOM/90T		G	POR	05-Aug-09	21-Jul-09	208	(4)	(8)	1.8	0.0	0.0	1,087	2,339	2,564
1994	P	HOND	ACCORD EX		G	POR	06-Aug-09	03-Aug-09	208	(8)	7	1.8	0.3	0.3	1,087	1,574	1,448
1994	P	OLDS	88 ROYALE LS		G	POR	05-Aug-09	04-Aug-09	208	391	416	1.8	1.4	1.5	1,087	88	238
1994	P	PONT	BONNEVILLE SE		G	LAK	19-May-09	14-May-09	208	3	5	1.8	0.0	0.0	1,087	4,192	4,749
1995	T	JEEP	CHEROKEE SE	1	G	POR	05-Aug-09	24-Jun-09	208	67	89	1.8	0.3	0.1	1,087	1,779	2,226
1995	T	CHEV	K1500	2	G	POR	26-Jun-09	25-Jun-09	168	272	205	1.8	3.0	2.4	1,457	793	778
1996	T	DODG	DAKOTA	1	G	POR	24-Jul-09	21-Jul-09	100	96	34	1.0	0.4	0.6	893	2,055	1,946
1996	T	DODG	RAM 1500	2	G	POR	21-Jul-09	13-Jul-09	168	1,725	2,021	1.0	1.2	4.0	1,457	1,011	654
1996	P	PONT	BONNEVILLE SE		G	LAK	08-May-09	05-May-09	100	9,421	10,518	1.0	3.5	4.2	893	1,471	1,960
1997	T	FORD	F250	2	D	POR	09-Jul-09	25-Jun-09	168	15	(0)	1.0	0.1	(0.1)	1,457	2,194	2,736
1997	T	GMC	SAVANA G3500	2	G	POR	14-May-09	08-May-09	168	91	36	1.0	0.8	0.3	1,457	2,433	1,994
1997	P	CHEV	CAVALIER/RS		G	POR	26-Jun-09	25-Jun-09	100	116	142	1.0	1.0	0.5	893	2,082	1,470
1997	P	FORD	TAURUS GL		G	POR	16-Jun-09	15-Jun-09	100	(28)	11	1.0	0.1	0.1	893	1,396	1,155
1998	T	CHEV	S10	1	G	POR	14-Jul-09	24-Jun-09	100	99	87	1.0	0.5	0.9	893	2,103	1,505
1998	P	CHRY	SEBRING JX		G	LAK	08-May-09	04-May-09	100	126	128	1.0	0.5	0.7	893	1,544	1,444
1999	T	CHEV	ASTRO VAN	1	G	LAK	23-Jun-09	16-Jun-09	100	2,575	646	1.0	0.2	0.0	893	532	772
1999	P	FORD	CONTOUR SE		G	POR	25-Jun-09	26-Oct-07	100	50	39	1.0	0.6	0.2	893	1,610	1,543
1999	P	OLDS	CUTLASS GLS		G	LAK	07-May-09	23-Apr-09	100	411	330	1.0	6.2	6.6	893	245	409
2000	T	GMC	SAFARI	1	G	LAK	08-May-09	05-May-09	100	99	168	1.0	0.7	0.7	893	1,624	1,752
2000	T	FORD	F250 SUPER DUTY	2	D	POR	13-Jul-09	09-Jul-09	168	75	43	1.0	0.0	0.0	1,457	1,987	1,803
2000	P	VOLK	JETTA GLS		G	LAK	23-Jun-09	16-Jun-09	100	38	25	1.0	0.2	0.3	893	1,472	1,219

Table 5-4: High Emitters Requiring a Third Measurement

Year	Make	Body Style		Registration County		Date		HC Values			CO Values			NOx Values			
						Last	Prev	Std	Last	Prev	Std	Last	Prev	Std	Last	Prev	
A third reading is needed to verify high emitter status (The last two measurements exceed standard by less than the RSD tolerance).																	
1989	P	HOND	CIVIC LX		G	POR	14-Jul-09	13-Jul-09	264	243	299	1.8	0.2	0.3	1,243	1,649	1,482
1990	P	OLDS	DELTA 88 ROYALE BRO		G	POR	15-Jul-09	13-Jul-09	264	127	211	1.8	0.4	0.4	1,243	1,951	1,461
1991	P	OLDS	98 REGENCY ELITE		G	POR	06-Aug-09	04-Aug-09	208	8	(2)	1.8	0.2	0.2	1,087	1,387	1,318
1992	P	MERC	TOPAZ GS		G	LAK	26-Jun-09	25-Jun-09	208	13	9	1.8	0.0	0.0	1,087	1,225	1,660
1993	T	GEO	TRACKER	1	G	POR	24-Jul-09	13-Jul-09	208	7	46	1.8	0.3	0.5	1,087	1,976	1,155
1993	P	MAZD	PROTEGE DX		G	POR	06-Aug-09	05-Aug-09	208	65	122	1.8	0.2	0.3	1,087	1,806	1,178
1993	P	MERC	TRACER		G	POR	02-Jul-09	30-Jun-09	208	(15)	2	1.8	0.1	0.1	1,087	1,392	1,255
1993	P	NISS	SENTRA E/SE/SE		G	LAK	07-May-09	05-May-09	208	60	102	1.8	0.1	0.1	1,087	1,123	1,431
1994	T	FORD	RANGER	1	G	POR	06-Aug-09	14-Jul-09	208	(10)	8	1.8	0.5	0.0	1,087	1,147	2,712
1994	P	HOND	ACCORD LX/EX		G	LAK	15-Jun-09	12-Jun-09	208	(34)	(9)	1.8	0.2	0.2	1,087	1,186	1,368
1995	P	CADI	ELDORADO		G	POR	14-Jul-09	13-Jul-09	208	29	40	1.8	0.1	0.1	1,087	1,209	2,041
1995	P	PONT	GRAND AM SE		G	LAK	23-Jun-09	12-Jun-09	208	87	104	1.8	0.5	0.5	1,087	1,967	1,198
1995	P	SATU	SC2		G	POR	04-Aug-09	30-Jun-09	208	6	85	1.8	0.0	0.4	1,087	1,137	1,650
1996	P	BUIC	PARK AVENUE		G	LAK	19-May-09	07-May-09	100	(6)	11	1.0	0.1	0.4	893	897	1,023
1996	P	BUIC	CENTURY SPECIAL/CU		G	POR	21-Jul-09	14-Jul-09	100	49	59	1.0	0.4	0.5	893	1,182	918
1996	P	CHEV	LUMINA LS		G	LAK	09-Jul-09	02-Jul-09	100	71	70	1.0	0.3	0.4	893	915	1,094
1997	T	FORD	F150	1	G	LAK	08-May-09	05-May-09	100	163	156	1.0	1.0	1.6	893	32	(90)
1997	P	FORD	TAURUS GL		G	LAK	08-May-09	05-May-09	100	166	199	1.0	1.2	0.8	893	1,024	958
1997	P	PLYM	BREEZE		G	LAK	19-May-09	05-May-09	100	136	113	1.0	0.7	0.4	893	450	438
1998	T	FORD	RANGER	1	G	POR	27-Jul-09	24-Jul-09	100	7	2	1.0	0.2	0.1	893	1,019	1,462
1998	T	TOYO	4RUNNER SR5	1	G	LAK	23-Jun-09	15-Jun-09	100	(20)	0	1.0	(0.0)	0.0	893	1,010	1,421
1998	T	DODG	RAM VAN B1500	2	G	LAK	23-Jun-09	16-Jun-09	168	56	44	1.0	0.6	0.6	1,457	1,574	1,634
1998	T	FORD	EXPEDITION	2	G	LAK	05-Aug-09	04-Aug-09	168	9	(6)	1.0	0.1	0.1	1,457	1,633	1,510
1998	P	VOLK	GOLF GL		G	POR	04-Aug-09	16-Jul-09	100	15	(2)	1.0	0.4	0.3	893	1,799	1,066
1999	T	CHEV	ASTRO VAN	1	G	POR	23-Jun-09	12-Jun-09	100	172	128	1.0	1.1	0.7	893	1,179	1,057
1999	T	OLDS	SILHOUETTE	1	G	POR	08-May-09	07-May-09	100	(17)	11	1.0	0.2	0.0	893	903	2,692
2000	T	CHEV	BLAZER	1	G	POR	03-Aug-09	09-Jul-09	100	6	(18)	1.0	0.0	0.1	893	894	1,117
2000	T	FORD	RANGER	1	F	POR	16-Jul-09	14-Jul-09	100	(25)	(23)	1.0	0.0	0.1	893	1,081	980
2001	P	BUIC	REGAL LS		G	LAK	07-May-09	04-May-09	100	98	55	1.0	0.4	0.6	893	1,372	1,047
2001	P	VOLK	NEW BEETLE GLS TDI		D	POR	27-Jul-09	13-Jul-09	100	17	50	1.0	0.3	1.2	893	969	951
2002	T	CHEV	EXPRESS CUTAWAY G	2	G	LAK	06-May-09	05-May-09	168	310	139	1.0	0.3	0.2	1,457	1,509	1,556

Table 5-5: Suspected High Emitters With a Third Measurement

Year	Make	Body Style	Registration County	Date			HC Values				CO Values				NOx Values				Confirm
				Last	Prev	2nd Prev	Std	Last	Prev	2nd Prev	Std	Last	Prev	2nd Prev	Std	Last	Prev	2nd Prev	
1988	HOND	CIVIC CRX HF 1.5	POR	13-Jul-09	30-Jun-09	26-Jun-09	264	286	521	321	1.80	6.6	5.4	0.8	1243	496	548	2,453	Y
1990	CHEV	CORSICA LT	LAK	16-Jun-09	15-Jun-09	12-Jun-09	264	178	167	261	1.80	0.5	0.4	0.5	1243	2,584	2,053	1,898	Y
1991	CHRY	LEBARON	POR	29-Jun-09	26-Jun-09	24-Jun-09	208	176	78	131	1.80	0.6	0.2	0.3	1087	2,156	2,391	3,259	Y
1991	OLDS	98 REGENCY ELI	POR	06-Aug-09	04-Aug-09	03-Aug-09	208	8	-2	7	1.80	0.2	0.2	0.3	1087	1,387	1,318	383	
1993	BUIC	LESABRE CUSTC	POR	05-Aug-09	21-Jul-09	09-Jul-09	208	-4	-8	6	1.80	0.0	0.0	0.0	1087	2,339	2,564	2,116	Y
1993	MAZD	PROTEGE DX	POR	06-Aug-09	05-Aug-09	04-Aug-09	208	65	122	67	1.80	0.2	0.3	0.3	1087	1,806	1,178	857	
1993	JEEP	CHEROKEE COU	POR	27-Jul-09	21-Jul-09	14-Jul-09	208	60	59	29	1.80	0.4	0.5	0.2	1087	1,938	2,053	1,694	Y
1994	HOND	ACCORD EX	POR	06-Aug-09	03-Aug-09	09-Jul-09	208	-8	7	5	1.80	0.3	0.3	0.3	1087	1,574	1,448	1,456	Y
1994	PONT	BONNEVILLE SE	LAK	19-May-09	14-May-09	05-May-09	208	3	5	-2	1.80	0.0	0.0	0.1	1087	4,192	4,749	1,198	Y
1994	OLDS	88 ROYALE LS	POR	05-Aug-09	04-Aug-09	26-Jun-09	208	391	416	-7	1.80	1.4	1.5	0.0	1087	88	238	9	
1996	DODG	DAKOTA	POR	24-Jul-09	21-Jul-09	13-Jul-09	100	96	34	107	1.00	0.4	0.6	0.6	893	2,055	1,946	2,372	Y
1997	PLYM	BREEZE	LAK	19-May-09	05-May-09	23-Apr-09	100	136	113	318	1.00	0.7	0.4	3.1	893	450	438	810	Y
1997	GMC	SAVANA G3500	POR	14-May-09	08-May-09	07-May-09	168	91	36	32	1.00	0.8	0.3	0.4	1457	2,433	1,994	2,104	Y
1998	CHRY	SEBRING JX	LAK	08-May-09	04-May-09	23-Apr-09	100	126	128	1763	1.00	0.5	0.7	0.5	893	1,544	1,444	1,483	Y
1999	OLDS	SILHOUETTE	POR	08-May-09	07-May-09	05-May-09	100	-17	11	19	1.00	0.2	0.0	0.1	893	903	2,692	1,597	Y
2000	CHEV	BLAZER	POR	03-Aug-09	09-Jul-09	02-Jul-09	100	6	-18	-6	1.00	0.0	0.1	0.0	893	894	1,117	99	

6 Clean Vehicles

The emissions distributions in Section 3 showed that the vast majority of vehicles are clean. Figures 6-1 and 6-2 show decile emissions within model years for HC and NO emissions. In the charts, the 1995 and older models were compressed into two groups because few vehicles were measured for each individual model year of these older models. The charts further illustrate that most of the newer model vehicles have very low emissions. Since, 1996 and newer OBD-II equipped vehicles inform their owners if faults are detected in emission control system components, owners of these models are generally aware of whether their vehicle needs service. Exceptions are faults such as fuel leaks that are not detected by OBD-II but register as high RSD HC emissions on-road.

The on-road measurements, in addition to identifying high-emitters, provides a way of reducing the I/M burden for owners that keep their vehicles well maintained and are responsive to the OBD-II check engine warnings. A Clean Screen program uses RSD measurements to exempt these vehicle owners from a station inspection and allows the funds that would otherwise be spent on station visits to be directed toward the on-road measurements, thereby allowing comprehensive on-road monitoring, and toward support of other emission reduction activities such as repair and scrap programs. The wealth of on-road measurements can be used to focus on the residual high exhaust and high evaporative emitters through notifications and repair/scrap assistance programs. The net result is more convenience for owners of clean vehicles and a stronger focus on the small percentage of high emitting vehicles.

Figure 6-1: Decile HC Emissions

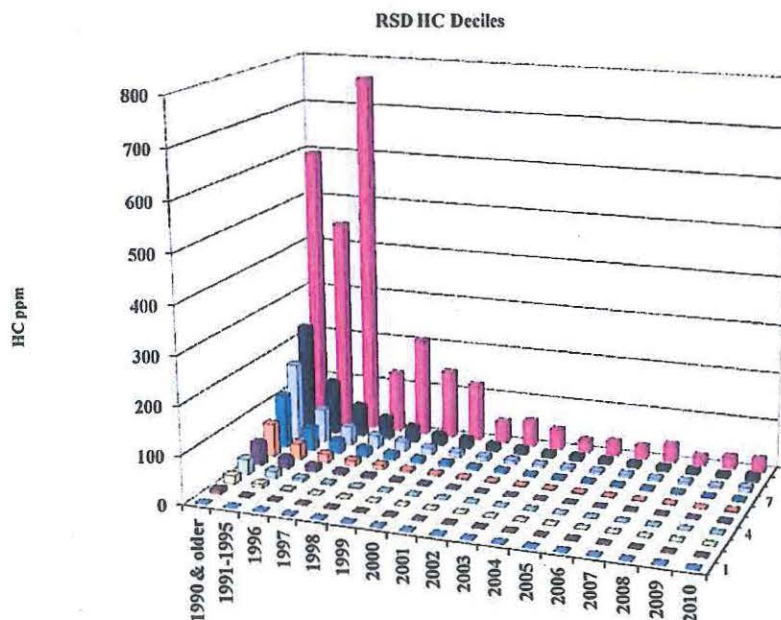
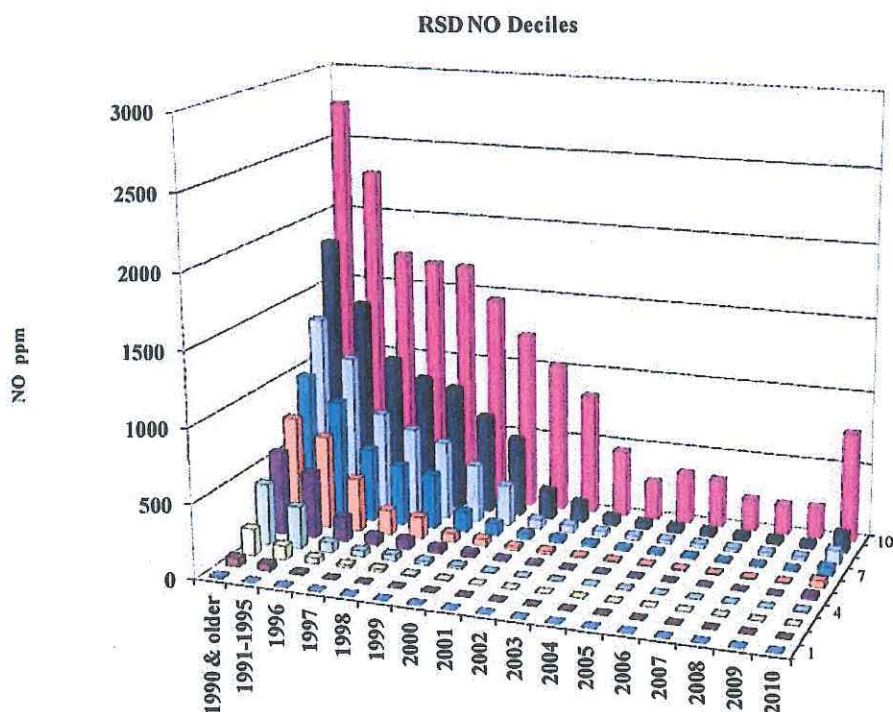


Figure 6-2: Decile NO Emissions

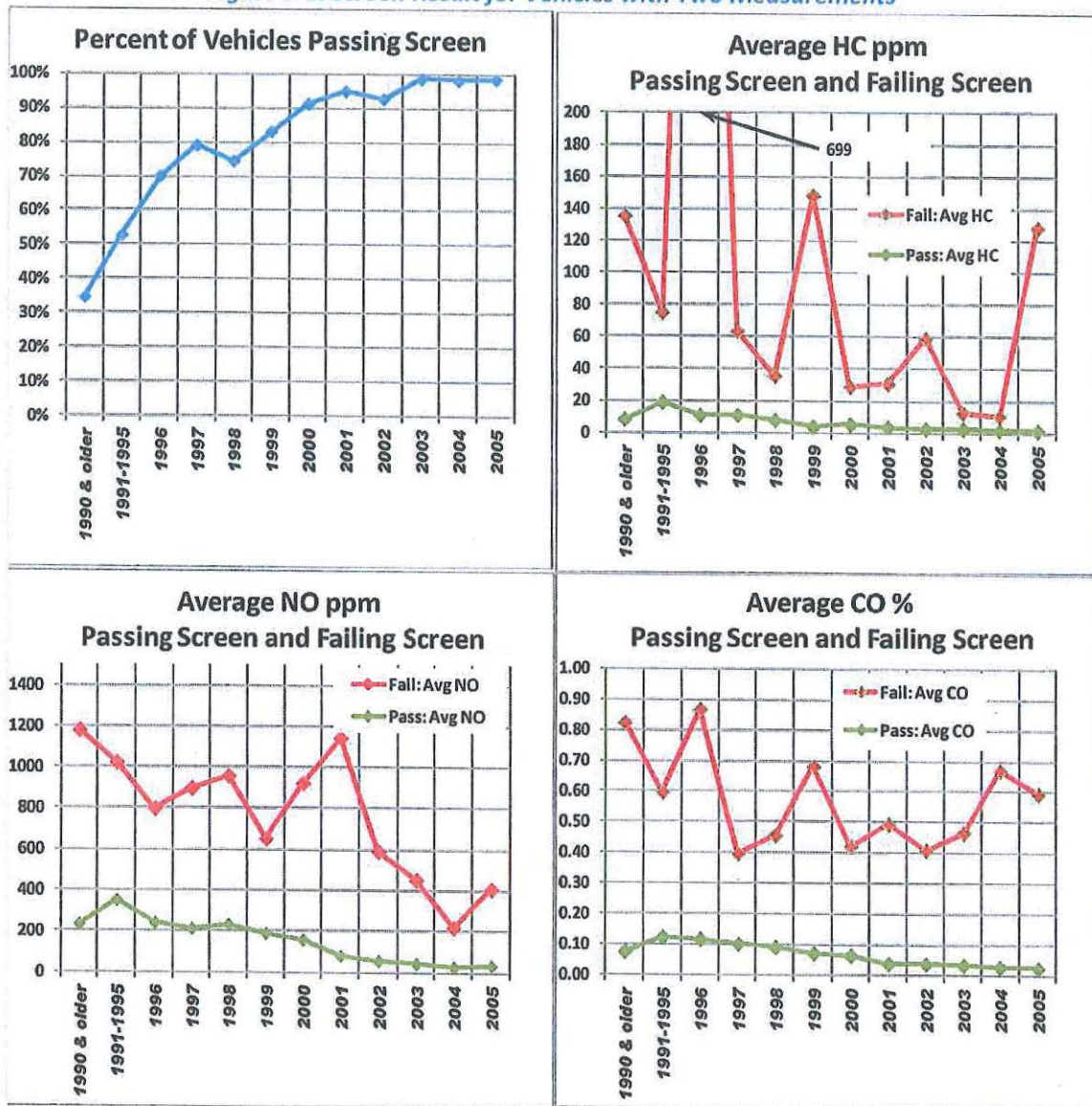


Colorado has been running a successful clean screen program in the Denver Metro Area (DMA) since 2003. Current Clean Screen criteria require vehicles to have two RSD measurements with emissions below 200 ppm HC, 0.5% CO and 1000 ppm NO. Vehicles may also pass with a single measurement if the historical fail rate for the model is low.

Figures 6-3 shows by model year the % of Indiana vehicles with two measurements that passed the Colorado criteria and the average emissions of those passing the screen vs. those failing the screen. The average emissions of those passing the screen were nearly all less than 15ppm HC, 250 ppm NO_x and 0.1% CO. The vast majority of excess emissions identified by I/M remained in the vehicles failing the screen.

A pilot Clean Screen program was recently started in Tennessee and other air districts and state agencies have expressed interest. A pilot program is a good way for states to test effectiveness of a remote sensing clean screen.

Figure 6-3: Screen Result for Vehicles with Two Measurements



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